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ABSTRACT

Described is the Mathematics component of the Iowa Developed Energy Activity Sampler (IDEAS), a multidisciplinary energy education program designed for infusion into the curriculum of grades 7-12. Also included in the prcgram are activity sets for Home Economics (SE 034 678), Industrial Arts (SE 034 679), Language Arts (SE 034 680), Science (SE 034 682), and Social Studies (SE 034 683). Contained in this manual are the 22 student-centered activities from the complete IDEAS curriculum that relate to secondary mathematics. Lesson plans include background information as well as worksheets, diagrams, and equations to aid in computation. Activities are arranged under six concepts: (1) Energy is basic: (2) Energy usefulness is limited: (3) The environment is affected by energy exchanges: (4) Energy choices affect society: (5) Conservation: and (6) The future is ours to shape and share. Among the topics addressed are energy units and measurement, perscnal energy expenditures, fuel supply and demand, exponential growth, and energy consumption in agriculture and manufacturing. (Author/WB)

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I. D. E. A. S.

for

Mathematics

SE 034 681

Iowa Developed Energy Activity Sampler

Sponsored by:

Iowa Energy Policy Council
in cooperation with
Iowa Department of Public Instruction

1980

Iowa Developed Energy Activity Sampler Grades 7-12

1980

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This notebook is one of a series of six notebooks which include the subject matter areas of home economics, industrial arts, language arts, mathematics, science, and social sciences.

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Education and Energy

Background:

We live in a sea of energy, a balance of delicate and powerful forces that are so much a part of daily experience that their rhythm is often ignored. Life itself is energy conversion--intimate, dynamic, natural, precious, and taken-for-granted. Energy? We live it, use it, give it, and are suddenly surprised to discover that it is related to

--high prices;
--short supplies of basic goods and services;
--lack of national self-sufficiency;
--industrial, technological, educational systems;
--time and materials use;
--mobility, lifestyles, environmental problems, future options;
--quantity and quality of life.

Definition of the Problem:

Modern industry, agriculture, and transportation systems make possible a standard of living that is dependent upon cheap, easily transportable energy sources. Use of inherited energy capital (fossil fuels) for expanded industrial and agricultural production has supported a population that is now far larger than that which existed throughout the world's previous history, and the population is still growing. Moreover, individuals are using increasing amounts of fossil fuels as they acquire more manufactured articles and adopt energy-intensive lifestyles.

Strategy:

The framework used in developing the following activities is the "infusion" model. Recognizing that various aspects of energy education fit well into existing disciplines--especially (but not exclusively) the sciences, social sciences, home economics, mathematics, industrial arts, and language arts--the Iowa Energy Policy Council and the Energy Education Advisory Committee hope that individual teachers will choose activities that complement and extend the topics usually covered or the skills to be developed and strengthened in their classes.

Some suggestions may stimulate cooperative multidisciplinary or interdisciplinary activities as well. Energy education is interdisciplinary because every area of human endeavor depends on energy. The emphasis on energy as a basic consideration for every aspect of life will put a new perspective on much human knowledge and show a "connectedness" that was not obvious before. Energy choices are not only technological ones; they are likely to have multivariate effects on personal and international economics, the environment, and its capacity to safely sustain us, the materials our children may hope to use, and the lifestyle options that future generations may have.

A variety of approaches is recommended for teaching about energy. The activities included are just a few examples of the ways to stimulate an energy awareness, new perspectives on the interdependencies of people and other living things, and recognition of human value/choice/action synergies that will shape the future. Teachers and students can demonstrate, experiment, build, discuss, debate, survey, role-play, write, draw, research, explore, brainstorm, consider alternatives and consequences, model, investigate, measure, calculate, dramatize, and display progress in understanding energy and in practicing less wasteful energy use.

Energy flows in all directions throughout the physical world, but some of it comes to a focus in the biosphere and in the flowering of human culture. It seems natural that energy awareness should also grow by a gathering of illuminations from various sources, both practical and theoretical, and should involve many skills. Ideally, energy education will foster curricular integration, will help develop a conservation ethic, and will challenge the inventiveness and initiative of creative minds.

Summary of Energy Education Concepts

1. Energy is basic.

Energy exists in various forms and states.
Energy flows, transfers itself.
Life itself is energy conversion, a series of interactions with the physical world.
Humankind measures energy in various ways.

2. Energy usefulness is limited.

Laws of thermodynnamics describe physical constraints.
Natural resources are limited in amount and in usefulness. They require energy to extract, so "net yield" accounting is necessary for future developments.
Exponential rate of using cannot continue.
Economics dictate some restrictions.

3. Environment is affected by energy exchanges.

Mined (fossil) energy measurably disrupts natural systems during
a. extraction
b. transportation and distribution
c. consumption (including electrical generation).
Capturing solar and wind energies may require new materials, non-traditional land allocations, and population shifts with unknown side-effects on global environment.
All other energy alternatives also will cause varying degrees of environmental change.

4. Energy choices affect society.

Energy is the true basis of economics.
Lifestyles vary with energy use.
Employment patterns vary with energy availability.
Life, health, and literacy have been correlated to energy consumption.
International relations and trade are directly influenced by energy distribution.
World inequities in energy supplies suggest future challenges and priorities.

5. The case for conservation.

There is a need to conserve and "buy time" for a more gradual energy transition and development of alternatives.
The relative importance of energy-using activities must be considered:
a. actual needs
b. perceived needs
c. non-essential uses
Ways to reduce energy consumption must be explained and demonstrated.

6. The future is ours to shape and share.

Time-sense must be developed, the present in relation to past and to projections for the future:
a. mid-term of "one generation" or ~ 30 years.
b. long-term alternatives and possibilities.
Dreams for the future are the only realizable ones. Without them we act blindly.

"Quality of life" may be redefined.

Teaching the Energy Lesson

The activities included in this publication are not a special step-by-step "course." Rather, they are suggestions to get interested teachers started on the process of incorporating energy concepts into existing classes.

The concepts represented by particular articles and activities include those outlined under Summary of Energy Education Concepts. Briefly, they are that:

1. Energy is basic.
2. Energy usefulness is limited.
3. Environment is affected by energy exchanges.
4. Energy choice affects society.
5. Conservation is essential.
6. The future is shaped by today's decisions.

Some of the activities are teacher-directed or demonstrated. Others are student-centered, chances to handle materials or information and to observe events that might otherwise go unnoticed. This second category of activities is the more important for intellectual maturation of the student.

Too many students have never observed a ball repeatedly rise and fall, nor seen fresh bread dough expand. They don't know which way the wind blows. They've never taken apart a battery, a camera, or a gear system. They've never considered other lifestyles either, nor the social and environmental effects of exponential increases in energy use. They should get their hands and minds exposed to human variables as well as physical ones. After students handle materials and manipulate viewpoints, they may be ready for more formal analyses and (hopefully) will come to see social and environmental dynamics with new insights.

The limited research done so far on teaching energy conservation and need to change patterns of energy use suggests that practical experience is necessary. Measuring energy use at home and school, installing insulation or making a solar collector, experimenting with small changes in lifestyle, and exchanging viewpoints with others whose hobbies, habits, and career choices may be or have been affected by energy futures seem to be effective means of encouraging young people to make energy-use changes in their own lives.

Science and technology are important in outlining limits to energy alternatives, safety, storage, and environmental insults. However, national proposals that

call for major commitments to the development of more and more energy (delaying transition) draw attention away from the more significant social issues of energy distribution inequities, economic pressures, political repercussions, and international tensions. There are complex synergies whose existence are just becoming recognized, but are so much a part of the changing patterns of human life that they cannot be ignored. Therefore, this group of activities includes some that are related more to social studies and aesthetics than to pragmatic devices for measuring energy flows. This mix should emphasize the interdisciplinary and transdisciplinary nature of ENERGY to individual teachers.

Some of the articles prepared for this handbook are intended primarily for the teacher's information and background. If you want to introduce these topics to your students, adapt them any way you like.

Other articles "fit" more into one discipline than into another. Several are multidisciplinary, much depending on the emphases chosen by the teacher. Still others may involve other teachers, members of the community, families, or the school custodian. The summary and recommendations following are only suggestions, not limits. They may save time in making <u>initial</u> choices of activities to use in your classroom.

But don't stop there!

Energy Education:
General Objectives for Teachers

Successful energy education will encourage teachers:

1. To become knowledgeable about energy sources, uses, and conversions.

2. To recognize physical limits to energy availability and usefulness.

3. To recognize bases of human dependence on natural energy resources and the world-wide diversity of social responses to that relationship.

4. To become knowledgeable about environmental effects of energy exchanges and to recognize cost/benefit relationships and conflicts of values that need to be considered.

5. To know the "why" and "how" of energy conservation and to apply that knowledge.

6. To develop a forward-looking perspective; to broaden awareness of social, technological, and natural resource options; and to recognize the urgency of the need for planning.

7. To involve students in activities that help develop:

   a. their knowledge of energy relationships;

   b. their willingness to conserve and to make more productive use of resources;

   c. their awareness of value-bases for choices; and

   d. their talents for decision-making, planning, designing, and innovating that will affect the future.

Energy Education:
General Objectives for Students

Energy education will enable students:

1. To know more about energy sources, uses, conversions, and limitations.

2. To become aware of diverse, world-wide human responses to available energy resources.

3. To recognize that the environment is affected by energy exchanges, and that all energy use has costs as well as benefits for human society and its physical support system.

4. To develop a conservation ethic strong enough to be expressed in effective personal actions.

5. To acquire a sense of historical perspective that relates the present both to the past and to the future.

6. To develop decision-making skills and the confidence that personal and community choices and activities can affect the future in positive ways.

Key to Energy Activity Inventory

Type of Activity:

BI - background information for the teacher. All energy-educators should have this introduction, regardless of grade level or subject area.

TD - teacher-directed activities, like demonstrations or class discussions needing a moderator.

SC - student-centered activities, "hands-on" building or data-collecting experiences that can be done individually or in small teams. These often have directions and worksheets to be duplicated for student use. Teacher's notes usually supplement the student information, include hints on classroom management.

Subject Matter Areas:

HE - home economics

M - mathematics

IA - industrial arts

S - science

LA - language arts

SS - social sciences

Energy Activity Inventory

Concept: Energy is Basic

It exists in various forms and states that can be measured and appreciated in various ways. It flows and transfers itself. Life itself is energy conversion, a series of interactions with the physical world.

Title	Type	Subjects	Grades	Page
CALORIES, CALORIES	SC	HE, IA, S	9-12	
CANNED SUNSHINE	SC	HE, IA, S	7-12	
COLOR IT HOT	TD	IA, S	7-12	
ENERGY AND LANGUAGE ARTS	TD	LA, SS	7-12	
ENERGY AND LIFE	BI			19
ENERGY WORD GAMES	TD	HE, LA, S	7-9	
GETTING FACTS ON ENERGY USE	BI			21
GO WITH THE FLOW	SC	IA, S	7-9	
HEAT CAPACITY AND TEMPERATURE	BI			22
HIGH COST OF LIVING - I STUDY OF A HERBIVORE	SC	S	9-12	
HIGH COST OF LIVING - II STUDY OF AN AUTOTROPH	SC	S	9-12	
MEASURING ENERGY	TD	HE, IA, M, S	9-12	173
NEWS AND NOTES ON AGRICULTURE	BI			23
NEW/OLD IDEAS ON COOLING BY EVAPORATION	BI			25

Energy Activity Inventory

Concept: Energy is Basic

Title	Type	Subjects	Grades	Page
NOTES ON GRAPHS AND CHARTS	BI			27
PLANTS AND LIGHT ENERGY - I	TD	S	7-10	
PLANTS AND LIGHT ENERGY - II	SC	S	10-12	
POPSICLE POWER	TD,SC	S	7-12	
POTENTIAL ENERGY IN SUGAR	TD	S	10-11	
POWER PUFFS	SC	HE, IA, S	9-12	
RENEWABLE VS. NON-RENEWABLE ENERGY	TD	IA, M, S	7-12	179
SOLAR CLINOMETER	TD	IA, S	9-12	
SPOTTY POWERPLANT	SC	M, S	9-12	183
SUN FUN	TD	HE, IA, S	7-9	
SUN'S POSITION IN THE SKY	SC	IA, S	9-12	
UP WITH PEOPLE POWER	SC	IA, M, S	9-12	189
WAXING HOT	TD,SC	IA, S	7-12	
WORDS ABOUT ENERGY - I	SC	HE, S	9-12	
WORDS ABOUT ENERGY - II	SC	HE, LA, S, SS	9-12	

Energy Activity Inventory

Concept: Energy Usefulness is Limited

Laws of thermodynamics describe physical constraints. Natural resources are limited in amount and usefulness. They require energy to extract. Exponential growth cannot continue indefinitely.

Title	Type	Subjects	Grades	Page
ELECTRICITY AND NATURAL RESOURCES	TD	SS	9-12	
ENERGY AND LIMITS	BI			37
ENERGY AND EFFICIENCY	BI			41
ENERGY RESOURCES	BI			49
ENERGY RESOURCE SUMMARIES	BI			53
FUEL SUPPLY AND DEMAND	TD	M, S	9-12	193
GROWING TIME (Exponential Growth)	BI			67
LIGHT FANTASTIC, THE	BI			79
MODELING EXPONENTIAL GROWTH	SC	M, S, SS	10-12	195
PLANET EARTH: SOME MEASURED LIMITS	TD	M, S	10-12	205
SQUARING "ON THE DOUBLE"	TD	HE, M, S, SS	7-10	213
SUPER-TANKER EARTH	BI			81
THERMODYNAMICS: SOME BASIC ENERGY LIMITS	TD	HE, IA, S	7-12	

Energy Activity Inventory

Concept: The Environment is Affected by Energy Exchanges

Mined fuel disrupts natural cycles. Alternatives must be developed but they will also have varying degrees of social, cultural, economic, and environmental effects.

Title	Type	Subjects	Grades	Page
BLOWING IN SOME CENTS	SC	HE, IA, M, S, SS	8-12	217
ENERGY AND HOME SITE DEVELOPMENT	TD	HE, IA	7-12	
ENERGY DEBATE, THE	SC	LA, S, SS	8-12	
ENERGY AND POETRY	TD	LA, S	9-12	
GREENHOUSE EFFECT, THE	SC	IA, S	7-12	
HUMDRUM OR HOME DOME?	TD	HE, IA	7-10	
INVESTIGATING PASSIVE SOLAR HOME HEATING	TD	HE, IA	7-12	
MINI DRUM-WALL	TD, SC	HE, IA, S	7-12	
NUCLEAR FUSION	BI			85
SIMPLE SOLAR OVEN	SC	HE, IA, S	7-12	
SOLARIMETER, LET'S MAKE A	SC	IA, S	9-12	
SOLAR STILL, A	SC	IA, S	7-9	
WINDMILL, A CLASSROOM SAVONIUS	TD	IA, S	9-12	
WIND POWER	BI			89

Energy Activity Inventory

Concept: Energy Choices Affect Society

Lifestyles, employment, economics, quality of life, international relations, attitudes and choices are among elements directly related to energy use.

Title	Type	Subjects	Grades	Page
ENERGY AND STANDARD OF LIVING	TD	HE, S, SS	7-9	
ENERGY AND TRANSPORTATION	SC	HE, LA, SS	9-12	
ENERGY IN MANUFACTURING - I	SC	HE, SS	7-12	
ENERGY IN MANUFACTURING - II	TD	HE, IA, M, SS	9-12	221
ENERGY OPINIONS AND PRIORITIES	SC	LA, M, SS	7-12	225
HOW MANY HIDDEN HELPERS	BI			91
HOW NOW, DRY COW	SC	HE, M, SS	7-10	231
INTERDISCIPLINARY APPROACH	BI			96
LIFE STYLES AND ENERGY USE - I	TD	HE, SS	7-12	
LIFE STYLES AND ENERGY USE - II	SC	HE, LA, SS	9-12	
LIFE WITHOUT ELECTRICITY: A PEACE CORPS EXPERIENCE	TD	HE, M, S, SS	7-10	235
MAN, ENERGY, AND ENVIRONMENT: SOME ATTITUDES AND BELIEFS	TD	LA, S, SS	10-12	
NEWS WARM-UP	TD	LA, SS	7-12	
OIL EMBARGO AUCTION	TD	HE, SS	7-9	
OIL, TRADE DEFICITS, AND THE 51ST STATE	TD	SS	8-12	
SOME ENERGETIC FIGURING	SC	M	8-10	241
TRANSPORTATION FACTS	BI			99

Energy Activity Inventory

Concept: Conservation

Conservation means more productive use of necessary energy supplies and elimination of non-essential consumption. Careful use of fossil fuels can "buy time" for a more gradual energy transition.

Title	Type	Subjects	Grades	Page
BAKER'S DOZEN, THE	SC	HE, LA, S	7-9	
CABIN FEVER I SURFACE AREA	SC	HE, IA, M, S	8-12	247
CABIN FEVER II INSULATION	TD	HE, IA, M, S	7-12	253
CABIN FEVER III INFILTRATION	TD	HE, IA, S	7-12	
CABIN FEVER IV SITE AND PLANTINGS	TD	HE, S	9-12	
CABIN FEVER V HUMAN FACTORS	TD	HE, SS	9-12	
CHECKING WALL INSULATION	SC	HE, IA, S	7-9	
CONVENIENCE AND ENERGY	TD	HE, M	7-12	259
ELECTRICITY FOR FUN, CONVENIENCE, WORK	SC	HE, SS	7-9	
ENERGY AND AGRICULTURE	BI			100
ENERGY: WASTE AND PRODUCTIVITY	BI			103
FOOD-ENERGY CONSERVATION	SC	HE, S	10-12	
HOMES AND SCHOOLS' ENERGY EFFICIENCY	TD	HE, IA, M, S	9-12	261
ON THE ROAD TO ENERGY SAVINGS	SC	HE, IA, M	9-12	263
READING ELECTRIC METERS	SC	HE, IA, S, SS	7-12	
TRANSPORTATION: CARPOOLING SAVES	TD	HE, M, SS	7-12	275
WATERBAGS	TD	LA, S, SS	7-12	
WINDOW COVER PROJECT	SC	HE, IA, S	7-9	

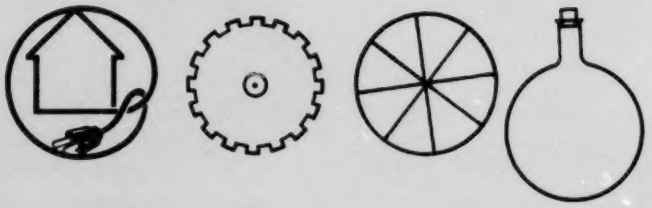
Energy Activity Inventory

Concept: The Future is Ours to Shape and Share

Time-sense must be developed, the present in relation to the past and to decisions affecting the future. "Quality of life" may be redefined.

Title	Type	Subjects	Grades	Page
ENERGY CONVERTERS AND POWER	TD	M, S, SS	10-12	279
ENERGY AND THE QUALITY OF LIFE	BI			106
ENERGY TRANSITION AND CHALLENGE	BI			113
ENERGY USE AND DECISION-MAKING	TD	HE, S, SS	8-12	
HISTORICAL DIGEST	SC	M, S, SS	9-12	289
TRENDS AND CONSEQUENCES: The Futures Wheel	TD	HE, S, SS	9-12	
YE OLDE TIMES, SUN PRESS, and STAR GAZETTE	TD	HE, LA, S, SS	7-12	

PAGES 19-172 CONTAIN THE INTRODUCTION. THEY HAVE BEEN REMOVED AND MADE INTO A SEPARATE DOCUMENT — SE 034 677.



Measuring Energy

Introduction:

There are many different units used to measure energy. The mix of terms used in various media can be confusing. Many of them are interchangeable, but some are not. How did such a jungle of jargon grow?

Background:

1. Various forms of energy were recognized and studied by different people in different countries. One researcher devised units for radiant energy, for example; others worked with electricity and gave their names to its measures; mechanical energy was quantified independently at a time when equivalence to other forms of energy was not recognized. We now realize that these units can be converted back and forth.

2. Two systems of measurement are involved. The eclectic British system borrowed measurement terms from many countries. The French devised a "universal one" based on powers of ten. Both systems have been widely used, with engineers in the U.S. usually using British terms like "B.T.U." and scientists using metric ones like "calorie".

3. Two different ideas, power and energy, are often used interchangeably in popular writing, adding to the confusion. Energy is the ability to make materials hotter, higher, or denser or to cause other changes. Power is a measure of how fast such transformations are done, or can indicate how concentrated the energy source is.

   There are two principal units of power, the horsepower and the watt. One horsepower is 550 foot pounds per second and a watt is one joule per second. Kilowatts and megawatts are 1,000 and 1,000,000 watts respectively, measures of flow of electricity. In order to know how much energy is used by a power source, the amount of time that power was used must be known.

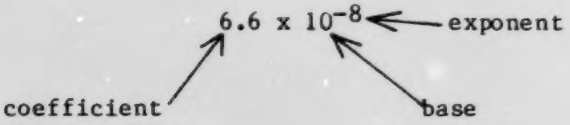
   Energy = Power x Time

4. Range of the units of energy varies. Some quantify very tiny transformations (like "electron volts") and others refer to gross consumption (like "quads"). Because of the wide range of energy measurements, including splitting of one uranium atom (.00000000001 Calories) and the annual heat output of the Sun (10,000,000,000,000,000,000,000,000,000,000,000,000,000 Calories) a convention has been adopted to make writing and computing with these numbers somewhat easier.

The shorthand way of expressing vary large and very small numbers is called POWERS OF TEN. One thousand (1,000) becomes 10^3 or 1 x 10 x 10 x 10. One million (1,000,000) becomes 10^6 and one billion is 10^9. The annual solar output becomes 10^{37}. The "exponent" or small raised number after the ten indicates how many tens were multiplied together (or how many 0's should follow the 1).

Very small numbers are indicated by a minus sign in front of the exponent.

Example:



The negative exponent indicates how many places to the left the decimal point should be placed. For the example above, the equivalent decimal is 0.000000066.

Common Units of Measure for ENERGY:

barrel: a liquid volume equal to 42 gallons or 159 liters or 0.159 m^3; usually used for petroleum

barrel of oil equivalent: an amount of energy typically contained in one barrel of petroleum--5.8 x 10^9 joules or 5.5 x 10^6 BTU or 1.39 x 10^6 Cal.

B.T.U. (British Thermal Unit): the amount of heat energy required to raise the temperature of one pound of water one degree Fahrenheit. One BTU is approximately equal to the amount of heat given off by a wooden match. A pound of coal contains approximately 13,000 BTU of chemical energy.

calorie: the amount of heat required to raise the temperature of one ml of water one degree Celsius.

Calorie: the kilocalorie or "food Calorie", the amount of heat necessary to raise the temperature of 1,000 ml of water one degree Celsius.

foot candles: unit of direct illumination at a given location, equivalent to the energy of light received on a surface at a distance of one foot from a standard candle. It is equal to one lumen per square foot.

foot-pound: English unit of mechanical energy, or work, the amount needed to lift one pound object one foot off the Earth.

horsepower: another unit of mechanical energy, the equivalent of 33,000 ft.-lbs. of work per minute (or 550 ft-lbs. per second) or 42.4 BTU's per minute. In electric power units, one horsepower-hour is about 0.75 kilowatt-hr.

joule: a metric unit of work, mechanical energy, and heat; approximately equal to 0.74 ft.-lbs. or 0.00096 BTU or 0.24 calorie. It is defined as the energy needed to raise a one kg. object one meter off the earth. It is also defined as the energy expended in one second by an electric current of one ampere in a resistance of one ohm.

kg coal equivalent: unit of heat energy often cited in U.N. statistics for comparison of solid, liquid and gaseous fuels. One kilogram coal equivalent is 7,000 Calories or 28,000 BTU.

Langley or Ly: unit of solar energy, radiation intensity equivalent to 1.0 calorie/cm^2. It can be used as a power unit when flow over time is expressed as Ly/min. or Ly/hr. or Ly/day. One Ly/min. = 221.2 BTU/hour/ft^2. One ly/min. also = 697.3 watts/m^2 or 16.74 kwh.

quad: the gigantic energy unit used to measure how much entire countries consume each year; it represents a quadrillion BTU's or the amount of energy in 172 million barrels of oil. United States citizens used about 78 quads of commercially supplied energy in 1979.

watt: a measure of electrical power, one joule per second. Wattage is a product of the voltage (measure of the "pressure" in an electrical circuit) and the amperes (current or flow of electricity). One volt and one amp applied to a circuit for one hour would use one watt-hour of electricity. One thousand (1,000) watt-hours or a kilowatt-hour is the unit most often used to measure electrical consumption. A 100 watt bulb burning for one hour has used 100/1,000 or 0.1 kwh of electricity. The same bulb lit for ten hours would use ten times as much power or one kilowatt-hour.

Activity Suggestions:

1. Use copies of Energy Unit Conversion Charts A and B for students' practice in handling "powers of 10". Provide Chart A and ask the students to rewrite each conversion factor in exponential form. Another day use Chart B as an "exam", asking students to rewrite each factor as a conventional integer or decimal.

2. Have students look through DOE pamphlets, extension service and utility company brochures and reports, popular magazine articles on energy topics, home utility bills, appliance handbooks or tags, science textbooks, and other available literature for examples of common usage of energy units.

a. Which unit(s) appear most often? Why?

b. Which is easiest to visualize or otherwise remember? Why do you think so?

c. If you could "standardize" energy units, what measurement would you use? Give a reason for your choice.

d. Why is it important to measure energy anyway?

3. Using mail order catalogs, appliance owners' handbooks, and automobile owners' manuals, identify the energy and power units used to describe various movers, heaters, and lights. Which items require the most energy for their use (daily, weekly, yearly)? Which require very concentrated energy sources? Which could operate or be made to operate on renewable resources?

Energy Unit Conversion Chart A

	Cal.	joule	kwh	BTU	ft.-lb.	hp.-hr.
Cal		4,200	.0012	3.97	3,090	.00156
joule	.00024		.00000028	.00095	0.74	.00000037
kwh	860	3,600,000		3,400	2,700,000	1.3
BTU	.252	1,055	.000293		778	.00039
ft.-lb.	.00032	1.4	.00000038	.0013		.0000005
hp.-hr.	640	2,700,000	0.75	2,500	9,980,000	
barrel of oil equivalent*	1,386,000	5,800,000,000		5,500,000		

Note. *Numbers have been rounded to two significant figures in most cases. Calorie is the kilocalorie or "food Calorie."*

*42 U.S. gallons.

Energy Unit Conversion Chart B

	Cal.	joule	kwh	BTU	ft.-lb.	hp.-hr.
Cal.		4.2×10^{3}	1.2×10^{-3}	4.0	3.1×10^{3}	1.56×10^{-3}
joule	2.4×10^{-4}		2.8×10^{-7}	9.5×10^{-4}	0.74	3.7×10^{-7}
kwh	8.6×10^{2}	3.6×10^{6}		3.4×10^{3}	2.7×10^{6}	1.3
BTU	2.5×10^{-2}	1.1×10^{3}	2.9×10^{-4}		7.8×10^{2}	3.9×10^{-4}
ft.-lb.	3.2×10^{4}	1.4	3.8×10^{-7}	1.3×10^{3}		5.0×10^{-7}
hp.-hr.	6.4×10^{2}	2.7×10^{6}	0.75	2.5×10^{3}	2.0×10^{6}	
barrel of oil equivalent*	1.4×10^{6}	5.8×10^{9}		5.5×10^{6}		

Note. *All figures are rounded to 2 significant figures.*

42 U.S. gallons.

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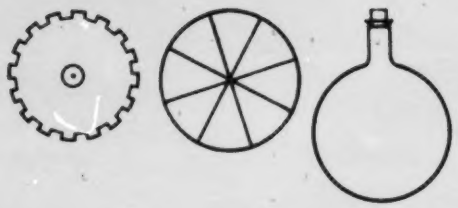


Renewable Vs. Non-Renewable Energy

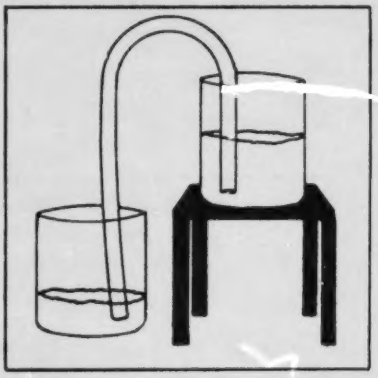
An Analogy

Materials:

Two or three pieces of flexible tubing or hoses of different diameters
Two large jars, aguaria, buckets, or other waterproof containers of similar size
Stopwatch or any watch or clock marking seconds
Water

Procedure:

Set one container on a desk or table and fill it nearly full of water. (If you want to do a quantitative analysis, measure or have students measure how much water is used.) Put the other container on the floor nearby. Fill one of the pieces of tubing (medium diameter) with water. Put one end under water in the upper container, as shown. Hold the other end closed until it is lowered into the floor-level container. Have a student secretary record the time as you release this hose and water begins to flow into the lower container. Instruct the secretary to also record the time when the water stops flowing.



Discussion:

Compare the water flow to energy flow. Consider these questions.

1. "Can the reservoir be refilled?" Literally, in the case of water or hydropower, it will be refilled if rains come periodically as expected. In the case of fossil fuels, no, nature's rate of manufacturing coal and petroleum in particular is so slow that it seems like "never" to humankind. In the case of uranium ores, the answer is also "no." In the case of sunshine, yes, the reservoir is likely to be refilled nearly everyday for billions of years.

2. "Can the flow be slowed?" Yes, use narrower tubing to make a given amount of energy-water deplete more slowly. Demonstrate this. Compare duration of flow (the time at finish minus time at start) to the duration of flow recorded for the original tube or hose.

   Some students may suggest raising the lower bucket to slow the flow. If you do this, be sure that you premeasure the volume of water in the original container and the volume of water delivered to the lower one as well as record the time. Then you have the data you need to figure whether the rate of flow changed (volume of water delivered/time) regardless of whether or not the total volume of water is delivered.

3. "Can the flow be increased?" Demonstrate this with a larger bore tubing or hose. Again record duration of the flow. Compare results to our rate of use of sources of energy that are not renewable. Some of them, coal especially, could last hundreds of years if we do not increase the current rate of consumption.

Summary

Our history of using more and more fossil fuels per year, especially petroleum, is like increasing the bore of the siphon tube regularly. We are using up resources rapidly. Developing technology for using alternative energy sources and changing patterns of living, working, building, and traveling takes time. Slowing the rate of energy consumption would give us more time to make changes before fossil fuel supplies are unavailable.

A More Quantitative Approach:

If science or math is your specialty, you may want to develop a more mathematical basis for this analogy. Small increases in diameter of the tubing make sizable increases in the rate of flow. This can be used as an analogy to exponential growth, a key concept in environmental education and in economics as well. That is, small increases compounded over time quickly double any given quantity.

For this approach, be sure to use tubing that is comparable in every way except diameter. Flexible, smooth-walled plastic tubing is recommended. It is available from most pet stores, aquarium and scientific supply houses, and some hardware stores and it comes in 1/8", 1/4", 3/8", 1/2", and larger sizes.

Formulae for flow in pipes are complex, with variables of fluid resistance and rough and smooth boundaries. You can approximate differences in flow, however, by carefully timing (with stopwatch or digital watch) the duration required for water flowing from a certain diameter siphon tube to fill a plastic gallon jug or to fill a one liter graduated cylinder.

Some Questions to Investigate:

1. Can you calculate the rate of flow for each size of tubing? Use the formula: $\text{Rate of flow} = \frac{\text{volume delivered}}{\text{time}}$

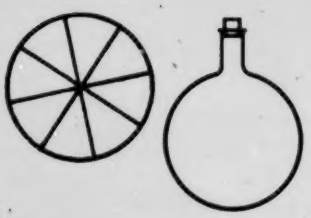
   Usually a rate per second is practical. To avoid a fraction in the numerator, use some equivalent units smaller than "gallon" and "liter." Keep in mind that one gallon = 4 quarts = 8 pints = 16 cups - 256 Tbsp. = 768 tsp. One liter simply = 1,000 ml.

2. As diameter of the tube is varied, does the rate of flow change arithmetically or geometrically?

3. Does this change correspond closely to the area of the tube opening or does it correlate better with the circumference of the opening?

4. Can you calculate the total surface area of the tubig in contact with the water? (Surface area of the tube will be circumference x length, or length x diameter x pi)

5. Would there be proportionately more friction potential (between the water and the plastic tube wall) in a larger diameter hose vs. a smaller one?



That Spotty Powerplant

Objective:

To learn more about behavior of the SUN, Earth's powerplant in the sky, and to look for patterns of change in its history.

Materials:

Graph paper, pencil
Record of annual sunspot numbers, 1906-1978

Procedure:

Look at the columns of numbers of sunspots for various years. Locate the largest and smallest numbers recorded in this time period. (The numbers are often fractions because they represent averages of those numbers reported by various observers around the world.) These indicate the range of numbers to be included on your graph.

Do the numbers listed increase or decrease over time? Is there a "trend" in the numbers? If yes, how long does the "trend" last?

The answers to these questions may be more obvious if you draw a picture of the numerical relationships. Such a picture is called a graph. Draw boundaries first, a vertical one near the left edge of your paper and a horizontal one near the lower edge. Label the vertical edge "number of sunspots" and put appropriate figures at regular intervals. (Always keep the same distance for a regular increase in numbers.) Then mark the intervals for the years on the horizontal axis. Put a point in the appropriate place for each year's data. Then connect the points.

Now use your graph to make the predictions necessary to answer the following questions:

1. What is the average time between the high points (periods of maximum sunspot activity) on your graph?

2. How many sunspots will there probably be this year?

3. What future years will be best for the next International Quiet Sun Year (time of minimum sunspots)? 1975-76 was such a period in the past.

4. In what year will the next maximum sunspot activity take place?

5. How old is the Sun compared to the length of your sunspot record? Is this sunspot record long enough to be a fair sampling of solar behavior?

ANNUAL SUNSPOT NUMBERS, 1906-1978

Year	Sunspot Number	Year	Sunspot Number	Year	Sunspot Number
1906	53.8	1931	21.2	1955	38.0
1907	62.0	1932	11.1	1956	141.7
1908	48.5	1933	5.7	1957	189.9
1909	43.9	1934	8.7	1958	184.6
1910	18.6	1935	36.1	1959	158.8
1911	5.7	1936	79.7	1960	112.3
1912	3.6	1937	114.4	1961	53.9
1913	1.4	1938	109.6	1962	37.6
1914	9.6	1939	88.8	1963	27.9
1915	47.4	1940	67.8	1964	10.2
1916	57.1	1941	47.5	1965	15.1
1917	103.9	1942	30.6	1966	47.0
1918	80.6	1943	16.3	1967	93.8
1919	63.6	1944	11.0	1968	105.9
1920	37.6	1945	33.2	1969	105.5
1921	26.1	1946	92.6	1970	104.5
1922	14.2	1947	151.5	1971	66.6
1923	5.8	1948	136.2	1972	68.9
1924	16.7	1949	134.7	1973	38.0
1925	44.3	1950	83.9	1974	34.5
1926	63.9	1951	69.3	1975	15.5
1927	69.0	1952	31.5	1976	12.6
1928	77.8	1953	13.9	1977	27.5
1929	65.0	1954	4.4	1978	92.5
1930	35.7			1979	155.4

Data provided by World Data Center A for Solar-Terrestrial Physics, National Oceanic and Atmospheric Administration, Boulder, Colorado 80303.

Teacher's Guide to That Spotty Powerplant in the Sky

Background Information:

The largest single powerplant serving Earth is located 93 million miles away. This nuclear fire called Sun releases energy from nuclear fusion. In solar fusion, nuclei of hydrogen atoms collide, uniting to form helium nuclei and releasing bursts of energy. Deep within the core of this reactor, 564 million tons of hydrogen are converted to 560 tons of helium each second. The remaining 4 million tons per second radiate away as heat and light.

Though these numbers sound very large, solar fusion goes on at a very slow pace compared to other energy conversions. Only because the Sun itself is so large does its energy output become enormous. Pound for pound, the Sun releases much less heat than the human body. How do we know this? It's a matter of arithmetic. The Sun's output of radiant energy, divided by the sun's mass, shows a daily production of two calories per pound (or .002 kilocalories, the food Calorie which is 1000 calories).* By contrast, the human body radiates about 10,000-15,000 calories or 10-15 Calories per pound per day. Maybe you have noticed how quickly a room warms up when people crowd into it for a party.

The Sun's activity is not entirely steady, however. The Sun seems to pulse, like a giant heart (Science News, April 21, 1979). Its granular complexion also has noticeable "spots" that vary in size and number from time to time.

When fog or haze reduce the glare of sunlight, careful observers can often see these large spots on the surface of the Sun. Chinese astronomers recorded sunspots for hundreds of years before telescopes were known in the western world.

Human metabolism converts chemical energy at a rate of .1 kwh hourly or 2.4 kwh daily, the equivalent of 2016 Calories for a person weighing 150-200 lbs.

Sometimes a sunspot lasts for only a few hours, but occasionally one will grow and persist for weeks and months. A relatively small spot measures only a few thousand miles in diameter, roughly the size of Earth. The largest spot on record (1947) expanded to more than seven billion square miles.

Spots are characteristically about 4200° C in their funnel-shaped center, hotter than the hottest blast furnace on Earth. Yet compared to the 5700° C temperature of the surrounding surface of the Sun, spots are cool and appear

**The solar statistics are MASS: 1.998×10^{30} kg or 4.38×10^{30} lbs. HEAT OUTPUT: 3.9×10^{23} kw per sec or 93.6×10^{23} kwh daily, the equivalent of 8.05 to 10^{30} calories or 8.05×10^{27} Calories.*

dark. They are also enormously magnetic and can cause radio and TV transmission difficulties. Lack of sunspots during "quiet Sun" periods has been associated with unusually cold weather.

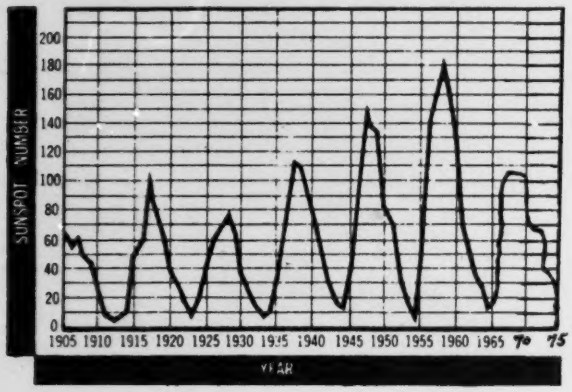
One of the most interesting features of sunspots is the apparent pattern in their appearances and disappearances. In records from the last two centuries, a regularity has been noted. However, 200 years is a very short time compared to the 5 billion years that scientists generally assume is the minimum age of the Sun. No one knows whether modern records describe a brief and temporary phase in solar history or whether this small sample is representative of typical solar behavior.

Four hundred scientists from 17 countries started making a special study of sunspots during "Solar Maximum Year," a project scheduled from August 1979, through February 1981. They hope to be able to improve forecasting of sunspots, solar flares, and other solar turbulence so that their effects on weather and shortwave communications can be anticipated.

Results of Student Activity:

The graphs should look approximately like the one at the right.

Graph showing the sunspot cycles



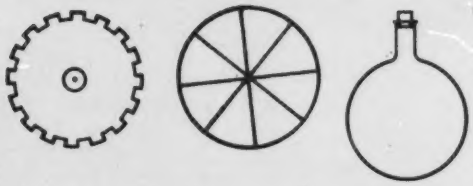
Question 1 can be answered either from the data directly or from the graph. Intervals between peak activity years, from 1907 on, are 10, 11, 9, 10, 10, and 11 years. The average of these intervals is about 10.1 years.

Question 2 depends on projection of the data on the current year. Answers will vary in magnitude but should be expected to "follow the trend." 1980's guesstimate, for example, can reasonably be expected to be at or near the peak. World Data Center A for Solar-Terrestrial Physics reported (on February 13, 1980) that their calculations suggest a probable value for the sunspot maximum is 160±14.

Question 3 requires checking intervals between "quiet Sun" years (1913, 1923, 1933, 1944, 1954, 1964, 1976). The sequence is 10, 10, 10, 11, 10, 10, 12 ----? Either 10 or 11 are reasonable expectations, so the year quoted would be 1986 or 1987.

Question 4 requires application of the answer to question 1. Either 1979 or 1980 is anticipated to be a maximum. Some students may assume that 1979 was a maximum and project the next one to be 1989 or 1990. Someone from the class may be encouraged to write the World Data Center (address on Sunspot Chart) for the most recent figures.

Question 5 directs attention to Sun's long history (at least 5 billion years) compared to man's very brief recording of it. The sunspot record provided for your students includes 74 years, only .000000015 of Sun's estimated age. If the Sun's duration is compared to the life of a 16-year old student, then this sunspot data is a seven-second episode. One astronomer claims that for a 70 year period from A.D. 1645 to 1715, sunspots were almost totally absent on the surface of the Sun, and the Earth experienced the chill of the "Little Ice Age." John A. Eddy's method of analysis and his conclusions on solar cycles are the subject of "When the Sun Went Strangely Quiet," Science News, vol. 109, March 6, 1976.



Up With People Power

Objective:

To relate personal energy expenditures to concepts of work and power.

Concepts:

Energy is the capacity to do work. Work is energy in use to move something. Power is the rate of doing work.

Materials:

Meter sticks
Bathroom scales (metric preferred)
Stopwatch, digital watch, or watch with second hand

Procedure:

1. Locate a stairway in your school or neighborhood where it is possible to climb two consecutive flights or one long flight without interruptions.

2. Taking turns with another student, climb these stairs slowly and steadily while your partner records stopping and starting times.

3. Calculate the total distance climbed by multiplying the height of one step (in centimeters or meters) by the total number of steps. Record this on the chart provided.

4. Measure or calculate each student's mass in kilograms (1 kg = 2.2 lbs. 1 pound = 0.45 kg). Record this on your chart.

5. Climb the stairs again, as fast as possible this time. Have your partner record the time. Then do the same for your partner. (If either of you has a health problem, one can do the leg work for both of you.)

6. The same amount of work was done each time you climbed the stairs, because the amount of material (yourself) and the distance it moved were the same. But the power required was different; power has a time factor in it.

Calculate the power required each time you climbed the stairs.

$$\text{Power} = \frac{\text{mass (kg) x distance (m)}}{\text{time (sec.)}}$$

Example: $\frac{65 \text{ kg x } 6 \text{ m}}{10 \text{ sec.}} = \frac{390 \text{ kgm}}{10 \text{ sec.}}$ = 39 kgm/sec. or 39 units of power

Use your figures now:

1. Climbing stairs slowly . . .

2. Climbing stairs rapidly . . .

Student Worksheet

Name _____

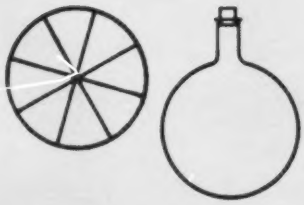
UP WITH PEOPLE POWER

Measurements & Calculations	Climbing Stairs	
	slowly	rapidly
3. a. height of one step (m)		
b. number of steps climbed		
c. total distance climbed (m)		
4. mass of student (kg)		
2. & 5. time required (sec)		
6. power required		

Use the back of this sheet for calculations if necessary. Put answers on the chart.

Compare the results (numbers) on the chart for climbing rapidly vs. climbing slowly. What do they tell you about energy, work and power?

Did you see or feel any difference between climbing slowly and climbing rapidly that does not show up on your chart?



Fuel Supply and Demand Relationships on Planet Earth

Avg. thickness of fuel layer	Yrs. of 2.8% use-rate increase	Yds. ^{3} of fuel per world citizen	Surface with fuel under it
feet 256			All - World
	350	8,000,000	
	325	4,000,000	
128			1/2 -
	300	2,000,000	
	275	1,000,000	
64			1/4 - Land
	250	500,000	
	225	250,000	
32			1/8 -
	200	125,000	
	175	64,000	
16			1/16 -
	150	32,000	
	125	16,000	
8			1/32 -
	100	8,000	
	75	4,000	
4			1/64 - U.S.A.
	50	2,000	
		1,000	
2			1/128 -
	25	500	
		250	
1			1/256 -
	10	125	
	5	64	
1/2			1/512 -
		32	
	1	16	
1/4			1/1024 -
		8	
		4	
1/8			1/2048 -
		2	
		1	
1/16			1/4096 -

Nomogram by Dr. Paul A. Smith
Coe College, Cedar Rapids, IA

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Teacher's Guide to Fuel Supply and Demand: A Nomogram

A nomogram is a kind of chart that can be used to graphically describe three related quantities. To use the one supplied here, have students decide how much of Earth's surface is likely to have fossil fuel under it (right hand column) and about how thick, on the average, these deposits may be (left hand column). As a point of comparison, the average coal seam is 3-6 feet thick. Using the nomogram, draw a straight line between these points. Read on the middle axis the number of years that the growing demand can be met.

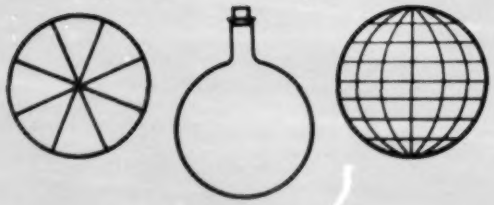
As examples, if one assumes that all land areas (1/4 of the Earth's surface) have fuel under them, and that the deposits average 1 ft. thickness, then the line crosses the middle axis around 125 years. That is how long the fuel would last under the assumption noted in the next paragraph. Or if one estimates that only one square mile per thousand has fuel under it, but that such deposits are 16 feet thick, then the intersection point is $\backsim$ 35 years; if deposits are 32 feet thick, they may last $\backsim$ 50 years.

In constructing this nomogram, Dr. Paul Smith assumed a world population of 4 billion people that would adopt the traditional American consumption pattern of 2.8% annual increase in total energy use (that is, doubling consumption every 25 years), starting at 13.6 cubic yards/person/year of fossil fuels or $\backsim$ 500 yds^3 per person the first 25 years.

This simplified graphic calculation does not account for growing population, another critical variable. There are already more than 4 billion people in the world and their numbers are increasing. Fulfilling expectations of American-style energy consumption will exhaust fossil fuel reserves much faster than the nomogram would suggest.

Use of the nomogram should help students realize that energy crises are likely to be with us on a long-range basis if we continue to depend heavily on mined, non-renewable resources. The hundred-plus years of American energy use and industrial expansion is an example of exponential growth that cannot last indefinitely on a space-ship Earth.

Dr. Paul Smith predicts, "So long as our rate of consuming energy continues to grow there is no way that technology can meet the long-range demands for energy nor deal with problems of thermal pollution. Energy consumption will stop growing and so will economic activities that depend upon increasing energy consumption."



Modeling Exponential Growth

by John W. Christensen*

Background:

Probably the most significant cause of the energy/environmental predicament is the phenomenon of exponential growth. Over the past few decades, population, nonrenewable resource consumption, food production, industrial output and pollution generation have all been increasing exponentially. To understand the energy and environmental crises, one must understand exponential growth. This activity is designed to give that understanding. It is built around the population problem, but can be applied to automobile production and disposal, electrical generating plant construction and demolition, etc.

Purposes:

To use dice to model exponential growth.

To change the variables and attempt to slow down and halt exponential growth.

Procedure:

In this activity you will use dice or colored wooden cubes to model population growth. Each die or cube represents a person. Each throw represents a year. The directions are written assuming you are using dice. If you use wooden cubes, make the substitutions shown below.

event	dice	cubes
birth	3 or 6	white, red
death	1	black

A "3" or a "6" represents the birth of a child, so each time one of them comes up, add a die to the population. If a "1" comes up, a death has occurred, so remove it from the population. Hence you are modeling a situation where the birth rate is twice the death rate. You also have a net population growth rate of 1/6 or about 17%.

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PART A: Unrestricted Exponential Growth (UEG)

Put six ordinary dice into a container (Adam, Eve, Cain, Abel, Sally, and Alice). Shake the container and dump the contents out onto a smooth, hard floor. Remove and count all the 1's that appear. Record the number of deaths on the chart for Part A. Count up all the 3's and 6's that appear. Since they correspond to births, add a die for each of them. Then fill in the required information in Chart A. Repeat this procedure until the total population exceeds 500 people.

PART B: The Effect of Instituting a Limited Birth Control Program (LBC):

Return to the year where your population first exceeded 100 people. Place that many dice into the container; but now introduce a limited birth control program. This will be modeled by having a "3" and every other "6" represent a birth. The remaining half of the 6's represent couples who are on contraceptives, so a birth has been prevented. If an odd number of 6's comes up, round-off in favor of a birth half of the time, and in favor of a prevented birth for the other half of the cases. Model this situation from where you start to the year 30, using Chart B. You have essentially cut the population growth rate from 17% to 8%.

PART C: The Zero Population Growth Plan (ZPG):

Again return to the year where your population first exceeded 100 people. Place that many dice into the container. But now introduce a large scale birth control program. This will be modeled by having <u>all</u> the 6's represent women using effective birth control techniques or women married to men using effective birth control techniques. Hence, a "1" represents a death, a "3" represents a birth, and a "6" represents a prevented birth. Model this situation from where you start to the year 30, using Chart C.

PART D: World Population Trends:

The following is a listing of estimates of world population (in millions), 1650 to 1978. Figures such as these are compiled by the United Nations and are published in most almanacs. Plot a graph of world population vs. time (1650 to 1978).

Population Estimates (millions)	
1650 = 470	1940 = 2,295
1750 = 694	1950 = 2,517
1850 = 1,091	1960 = 3,003
1900 = 1,571	1970 = 3,632
1930 = 2,070	1978 = 4,219 (est.)

PART E: The Nature of Exponential Growth:

Examine the following four facts about exponential growth and relate them to your graphs.

1. Exponential growth occurs whenever the rate of growth is directly proportional to the quantity of material present.

$$\frac{\Delta N}{\Delta t} \propto N$$

2. A quantity exhibits exponential growth when it increases by a constant percentage of the whole in a constant time period (like compound interest on a savings account).

$$\frac{\Delta N}{N} \propto \Delta t$$

3. Exponential growth is deceptive, because it starts out very slowly, but it is capable of generating immense numbers very quickly.

4. It is useful to think of exponential growth in terms of doubling time.

$$\text{Doubling Time (in years)} \cong \frac{70}{\% \text{ annual growth rate}}$$

The Characteristics of the Exponential Generation (1974):

Quantity	Annual Growth Rate (%)	Doubling Time (in years)
World Human Population	2.1	33
World Oil & Gas Consumption	7	10
World Industrial Output	7	10
World Food Production	1	70
Electric Power Gen. (U.S.)	9.25	7.6

Data:

Chart A: Unrestricted Exponential Growth (UEG)

Throw No. (Year)	Number of Births (Nb)	Number of Deaths (Nd)	Number of Dice Population	Population Growth Rate $\frac{\Delta N}{\Delta t} = \frac{Nb-Nd}{1} = \frac{\text{people}}{\text{year}}$
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
20				
30				

Data:

Chart B: The Effect of Instituting a Limited Birth Control Program (LBC)

Throw No. (Year)	Number of Births (Nb)	Number of Deaths (Nd)	Number of Dice Population	Population Growth Rate $\frac{\Delta N}{\Delta t} = \frac{Nb-Nd}{1} = \frac{\text{people}}{\text{year}}$
0	REMINDER:	Begin with the year your popultion first exceeded 100		
2		people.		
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
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21				
22				
23				
24				
25				
26				
27				
28				
20				
30				

Data:

Chart C: The Zero Population Growth Plan (ZPG)

Throw No. (Year)	Number of Births (Nb)	Number of Deaths (Nd)	Number of Dice population	Population Growth Rate $\frac{\Delta N}{\Delta t} = \frac{Nb-Nd}{1} = \frac{\text{people}}{\text{year}}$
0	REMINDER:	Begin with the year your population first exceeded 100		
1		people.		
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
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27				
28				
20				
30				

Graphs:

PART A: Unrestricted Exponential Growth (UEG):
Use your data to plot graphs of:
1. Population vs. Time (years)
   a. plot first on ordinary paper.
   b. plot again on semi-log paper.
2. Population Growth Rate vs. Time (years)
3. Population Growth Rate vs. Population

Note: If you are confused about which graphs to plot, see the graphing summary at the end of this section.

PART B: The Effect of Instituting a Limited Birth Control Program (LBC):
Use your new data to plot graphs of:
1. Population vs. Time, beginning LBC to year 30 (ordinary graph)
2. Population vs. Time, beginning of LBC to year 30 (semi-log graph)

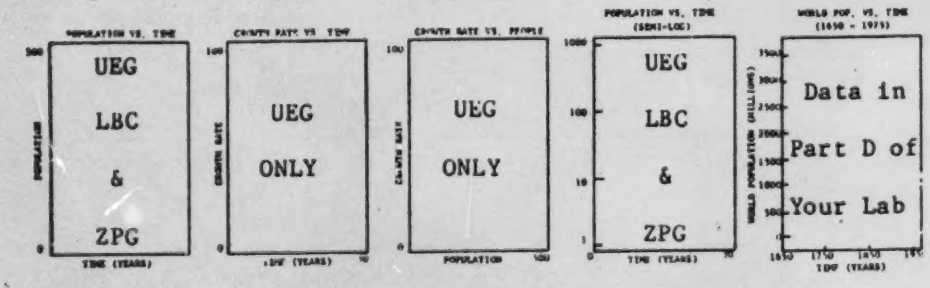
Plot these on the same graphs as in Part A, but use a different color.

PART C: The Zero Population Growth Plan (ZPG):
Use your data to plot graphs of:
1. Population vs. Time, beginning of ZPG to year 30 (ordinary graph)
2. Population vs. Time, beginning of ZPG to year 30 (semi-log graph)

Plot these on the same graphs as in Part A, but use a different color.

PART D: World Population Trends:
Plot a graph of World Population vs. Time (1650 to 1978).

The following is a summary of the graphs that are to be plotted for this lab:



Where: UEG = unrestricted exponential growth
LBC = limited birth control
ZPG = zero population growth

Write one conclusion for each graph.

Teacher's Guide to Modeling Exponential Growth

Discussion of Activity:

There is a connection between exponential growth and all of our energy/environmental crises. This activity should precede all discussion of exponential growth, population, consumption patterns and pollution generation.

In Part A, it takes about 20-25 minutes to build the population from 6 to 100 and only about 5 minutes to build it from 100 to 500, an important observation of quantities growing exponentially.

The activity is best accomplished in groups of six to eight students gathered around a table. Dividing up the labor saves a great deal of time and is a great exercise in group cooperation.

Materials:

Provide each table with a large can of 300 dice (or cubes). When the population grows beyond that, either roll twice or double your results. Most choose to double their results. For a class of 30 students, use four groups. Hence you need 1,200 dice. Purchase 1,400 to make up for losses and petty thievery.

Dice may be purchased at most variety stores. Painted wooden cubes work just as well and have several advantages over the dice:

1. They cost less.
2. Colors can be separated faster than numbers.
3. They are less likely to be stolen--especially if they are only painted on three sides.

Cut the dice from either 3/4" birch or maple--they soak up less paint and don't easily chip. From a board 3/4" x 2 ft. x 7.5 ft. you can cut approximately 1400 dice (allowing for the width of the table saw blade).

Before cutting, spray paint the board red on one side and black on the other. Then cut your cubes. Place all the cubes on a large sheet of paper unpainted side up and close together (no spaces between the cubes). Spray paint a third side white.

A source of ready-made hardwood cubes (plain ones - the red and white faces must be painted on) is Delta Education, Inc., Box M, Nashua, NH 03061, toll-free phone 1-800-258-1302. Their 1980 catalogue offers item CUB 001 (refill from Ice Cube Kit) a wooden cube set including 60 cubes 1 cm x 1 cm x 1 cm and 3 cubes 1/2" x 1/2" x 1/2" for $1.95 net to schools (per set). Shipping charges will be added to the invoice, f.o.b. Nashua, NH

BASIC UNIT PRICE ~ $.03

Larger hardwood cubes, 2 cm x 2 cm x 2 cm, are available in sets of 100 (Item 36620) from Creative Publications, 3977 East Bayshore Road, P.O. Box 10328, Palo Alto, CA 94303, phone 1-415-968-3977. Each set of 100 plain cubes is listed at $6.25 in their 1980 catalogue.

BASIC UNIT PRICE ≈ $.0625

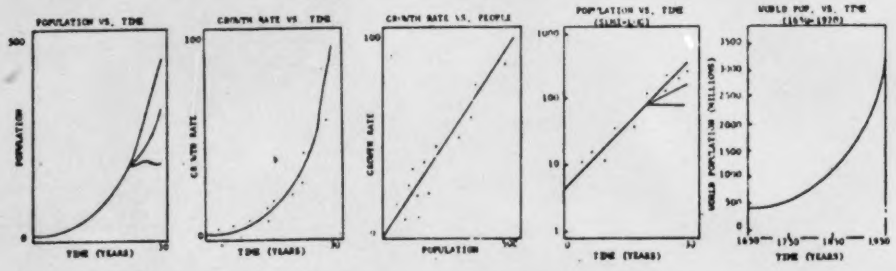
Game and toy stores sometimes sell dice in quantities, at a discount. For example, try Thinkers Emporium, 423 Brady Street, Davenport, IA 52803, phone 1-319-323-7117. In April 1980, their price to teachers for a gross (144) of quality dice, each 5/8" x 5/8" x 5/8", was $16.50. these require no further preparation or coloring. Mail order postage fee is an additional $1.50.

BASIC UNIT PRICE ≈ $.1150

You will need graph paper. This can either be purchased or crudely drawn out and duplicated.

Expected Results:

The sketches below represent typical results:



One problem some students have is with drawing the best line or smooth curve through their data in the case of Growth Rate vs. Time and Growth Rate vs. Population. A graphing review prior to this activity may be helpful.

If time permits, have some students plot a World Population vs. Time graph on semi-log paper, or at least show a plot of this in class. This will help answer the question: Is the rate of world population increase declining?

About one group in forty will start with so many deaths in their first few throws that their population never does increase. You may want to use their data as an example of a plague. If you don't wish to take the time to make this point, have the group begin again.

Sample Conclusions:

1. Population vs. Time

   When population grows exponentially and unchecked, it grows slowly when the population is small and then rapidly increases once a significant population base is established.

   The limited birth control program slows the overall growth; but since it is still exponential, it can get out of hand if given enough time.

   Only when the birth rate equals the death rate is the population growth checked.

2. Growth Rate vs. Time

   As the population increases, so does the growth rate. It appears that the growth rate also increases exponentially with time.

3. Growth Rate vs. Population

   Averaging out the randomness which is very pronounced when one deals with small numbers of objects, one can see that the best graph is a straight line which passes through the origin.

   Hence: Growth Rate $\propto$ Population

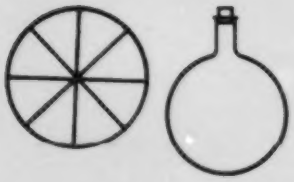
4. Exponential growth is indicated by a straight line on semi-log paper. This can serve as a test for exponential growth. The limited birth control program reduces growth, but the growth is still exponential. The ZPG plan stops expoential growth.

5. World Population vs. Time (1650-1978).

   This graph looks very similar to the one obtained for unrestricted exponential growth. World population increases slowly from 1650 to 1900, when technology and medicine were relatively undeveloped. However, after 1900, the curve shoots up rapidly. Now, world population increases more in a few decades than it did in a few centuries before 1900.

Discussion:

Discuss the graphs and the conclusions for each one. What you do from there depends upon your class, your priorities and the attitudes prevalent in your area. It is easy to say that exponential growth can be stopped by equating the birth rate to the death rate. How this is actually accomplished is another story altogether.



Planet Earth

Some Measured Limits

Introduction:

There are many conflicting opinions on how long our energy supplies may last. Some experts warn that the end of fossil fuels is already in sight--that is, within 20 years. Others are confident that there are nearly unlimited supplies, that "All we have to do is to hunt for them more aggressively." Some put the blame on legislation designed to restrict discharges into air and water. They assert, "If environmental restrictions were eased, we could use our energy more efficiently and make supplies last much longer."

Who is right? Doesn't anyone have facts that will tell us whether energy shortages are real? Maybe the whole thing is a plot by people who have political or economic motives for swaying public opinion.

In order to come to grips with the questionable basis of many energy-related statements appearing in the popular media, every citizen needs to know that:

1. All of Earth's resources are finite or limited in supply.

2. How quickly we use these resources is the prime factor in determining how long the supplies last.

3. Today's priorities and choices affect tomorrow's prospects.

None of these concepts are obvious on the basis of daily experience in our wealthy country. But they are so important to understanding of energy-related concerns that the effort to help students grasp these concepts must be made. The following group of activities centers on each of these ideas in turn.

Objective:

To familiarize students with the physical limits to fuel supplies inside planet Earth.

Method:

Provide each student with a copy of the chart, "Planet Earth: Some Measured Limits"; or project it on the overhead projector; or give students only the basic information (radius, deepest borehole) and let them derive others (circumference, volume, surface area).

Then, as a class, start deciding limits to the storage area for underground fuels.

1. Imagine Earth itself as one big oil tank (or tanker, if Spaceship Earth is a familiar metaphor). If Earth's "hold" were totally empty of rocks, oceans, metallic ores, magma, etc., how much fuel (maximum) could it contain?

   Most students can visualize this analogy. Having a globe or a basketball on hand helps, however. Figures to develop this comparison are included in a separate section, SUPER-TANKER EARTH. Use these numbers as you choose, either as a "given" or as a guide to simple calculations you can do with your class.

2. Start returning to reality. There is no evidence that Earth is hollow except for a few very tiny blisters we call "caves" or "salt mines." On the contrary, only a compact planet with increasingly dense materials as its core would behave as Earth does. Besides, Earth's average density is 5.5 (that is, five and one-half times as heavy as water, volume for volume) while the average density of most surface rocks is 3.0; coal's density is usually < 2.0; water is 1.0; natural gas is < 0.001.

   Another consideration is that limitations in methods, materials and costs restrict the depths people can reach by drilling. So far, the deepest borehole completed penetrates only six miles below the Earth's surface. So we must confine our search to the "outer skin" of Earth.

   How large is that "skin"? Either use the figures on the accompanying chart or involve the class in calculating the surface area of a sphere with a diameter of 8,000 mi or 12,800 km.

   Surface area = πd^2 So, using rounded figures,

   $A = 3.1416 \times 8{,}000 \times 8{,}000 = 2.01 \times 10^8$ mi.^{2}

   or, $A = 3.1416 \times 12{,}800 \times 12{,}800 = 5.15 \times 10^8$ km^2

   Using more exact figures,

   $A = 3.1416 \times 7{,}926 \times 7{,}926 = 1.97 \times 10^8$ mi.^{2}

   $A = 3.1416 \times 12{,}756 \times 12{,}756 = 5.11 \times 10^8$ km^2

   These results show the maximum surface to be explored.

3. Now, how much of that surface area is likely to have fuel under it? There is room for debate here.

   a. Consider that most exploration to date has been on land. Some drilling rigs are, however, tapping continental shelves including the North Sea. (Newer maps of the ocean floors show this area as supra-continental water, not true ocean.) Using World Book Encyclopedia figures provided, proportion of land areas to total surface area of the world is:

$$\frac{57.28 \times 10^6}{196 \times 10^6} \times 100\% = 29.1\%$$

If all continental shelves are added in, this "continental area" may be as much as 35%. The remaining deep oceans, or 65% of the surface area, can be excluded as having no fossil fuel potential. There is no geological evidence to date of reserves there.

b. Of the percent of surface area that possibly could have fuel under it (figure chosen in a.), how much (at most and at least) is likely to have fuel under it? Have the class vote on an upper and a lower limit. You may also want to remind students of the assumption that coal, petroleum and natural gas are all remains of luxuriant former life.

Is it reasonable to assume that all continental areas were densely populated with plants or animals and that all areas experienced the same conditions for burial and differential decomposition of this organic material?

Anyway, some possible choices for consensus might be that:

1 mi.^{2} or km^2 out of 10 has fossil fuel under it; or
1 mi.^{2} or km^2 out of 100, or
1 mi.^{2} or km^2 out of 1,000, or
1 mi.^{2} or km^2 out of 1,000,000, or
1 mi.^{2} or km^2 out of 1,000,000,000?

Encourage choice of both an upper and a lower limit. Then calculate the area(s) in square miles or square kilometers that these limits represent.

4. Now consider one other limitation. Granted that so much surface area may have fuel under it, how thick is the deposit likely to be? Let students decide. However, you may want to remind them of a few facts.

- Earth is only 4,000 mi. or 6,400 km "thick" from the center outwards.
- The greatest depth to which humans have explored the "rind" is six miles (deepest borehole was drilled in Oklahoma in 1974).
- Sixty-three percent of the coal mines in the U.S. are based on seams three feet to six feet thick.
- Depth of petroleum and gas pools can usually be measured in feet, yards, or meters. None over 50 yards are known.

Anyway, decide on some average depth. Then calculate the total volume of fuel reserves available by your class estimates.

Example: If you used mile units, your continental area calculations will be in the range of 57-70 x 10^6 sq. miles, depending when how much continental margin or shallow ocean area your students are willing to include. Let's use 60 x 10^6 mi^2 as a "ball park figure." Suppose the "range" of fuel-covering area (or the upper and lower limits chosen by the class) is one-tenth to one-millionth of that or 60 x 10^5 mi.^{2} (maximum) to 60 mi.^{2} (minimum) surface area.

Next, assume an average depth of 10 feet or 1/528 of a mile (0.0019 mi.) is selected as the average thickness of fuel deposits. Then the volume of deposits would be:

$(0.0019 \text{ mi.}) \times (60 \times 10^5 \text{ mi.}) = 0.114 \times 10^5 \text{ mi.}^3 = 11{,}400 \text{ mi.}^3$ (upper limit) and
$(0.0019 \text{ mi.}) \times 60 \text{ mi.} = 0.114 \text{ mi.}^3$ (lower limit)

5. Some conversions are now necessary. "Official" estimates of fuel reserves are usually calculated in barrels (for petroleum) or in metric tons (for coal). Therefore the next steps will be:

   a. Estimate how much of your fuel deposits are oil, how much are coal.

   b. Apportion volumes accordingly.

   c. Convert coal volume to metric tons. Assume that 1 m^3 coal deposit yields 1 metric ton or 2,200 lbs. of coal at the surface, or assume that 1 $yd.^3$ underground coal deposit yields 1 short ton (2,000 lbs.) of coal.

   d. Calculate the volume of petroleum (by your estimates) at the rate of 6.3 gal./m^3 or 5 gal./$yd.^3$.

6. Compare the class minimums and maximums with the "official world estimates." Use whatever resources are available to you. The local librarian is usually a good resource person who can locate current data. For your convenience, some estimates follow. These figures come from "Survey of World Energy Sources" by M. King Hubbert, reprinted in Perspectives on Energy, Ruedisili and Firebaugh, eds., New York: Oxford Press, 1978.

   Coal--Original world resources were estimated in 1969 (by Paul Averitt of the U.S. Geological Survey) to have been 7.64×10^{12} metric tons. Of this amount, M. K. Hubbert estimates that 2.35×10^{12} metric tons of it or 2.59×10^{12} "short tons" are recoverable, given present technology.

   Petroleum--Estimates for total ultimate recoverable crude oil in the world range from $1{,}350 \times 10^9$ to $2{,}400 \times 10^9$ barrels. (Divide by 6.3 gal. per m^3 or 5 per $yd.^3$

   Tar-sand oil reserves--These are estimated by Hubbert at 300×10^9 barrels.

   Shale-oil reserves--These are estimated by Hubbert at 190×10^9 barrels.

   Note: If you used metric measurements,
   $1 \text{ km}^3 = 1 \times 10^9 \text{ m}^3$
   If you used English measurements,
   $1 \text{ mi.}^3 = 5.45 \times 10^9 \text{ yd.}^3 = 1.47 \times 10^{11} \text{ ft.}^3$

Example: Converting Hubbert's figures to cubic yards for comparison to the class estimate figures given in miles (in previous example), we get the following:

Coal at 2.59×10^{12} tons and 1 yd.^{3} = 1 ton	2.59×10^{12} yd.^{3} coal
Petroleum at $2{,}100 \times 10^9$ barrels and 5 barrels = 1 yd.^{3}	0.42×10^{12} yd.^{3} petroleum
Tar sand oil at 300×10^9 barrels and 5 barrels = 1 yd.^{3}	0.06×10^{12} yd.^{3} oil from sand
Shale oil at 190×10^9 barrels and 5 barrels = 1 yd.^{3}	0.04×10^{12} yd.^{3} oil from shale
Total volume of fossil fuels stored under Earth's surface (excluding gas*).	3.11×10^{12} yd.^{3} (T_1)

*Gas was excluded because of lack of information on its subterranean volume. Its surface volume exceeds that of all other fuels because of its low density at atmospheric pressure. However, Hubbert has estimated that its contribution to the magnitude of energy stored underground is about 15.7%. From this can be calculated a "gas-equivalent" figure of about 0.58×10^{12} yd.^{3}, and T_2 or total volume of fossil fuels including gas = 3.69×10^{12} yd.^{3}.

$$T_2 = 3.11 \times 10^{12} \text{ yd.}^3 + 0.157\ T_2$$

$$0.843\ T_2 = 3.11 \times 10^{12}$$

$$T_2 = \frac{3.11 \times 10^{12}}{0.843} = 3.69 \times 10^{12} \text{ yd.}^3$$

$$15.7\%\ T_2 = 0.579 \times 10^{12} \text{ or } 0.58 \times 10^{12} \text{ yd.}^3$$

Using T_1 and the figure 5.45×10^9 yd.^{3} = 1 mi.^{3},

$$\frac{3.11 \times 10^{12}}{5.45 \times 10^9} = 0.57 \times 10^3 \text{ mi.}^3 \text{ or } 570 \text{ mi.}^3$$

Using T_2, the calculations are:

$$\frac{3.69 \times 10^{12}}{5.45 \times 10^9} = 0.677 \times 10^3 \text{ mi.}^3 \text{ or } 677 \text{ mi.}^3$$

These totals fall halfway between the 11,400 mi.^{3} upper limit and the 0.114 mi.^{3} lower limit of the original example (point 4).

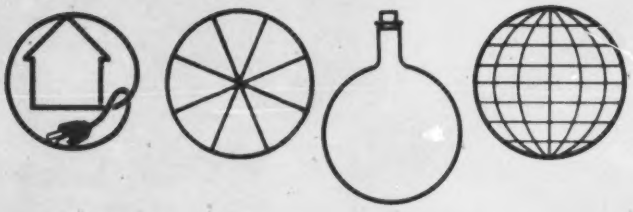
7. When the class has successfully totaled their estimates of the volumes of fossil fuel available, the next important question is "How long will it last?" Surprisingly, the amounts of fuel estimated by the class and by the experts--even though they may differ by factors of two, four, ten, or more--will last nearly the same amount of time IF the same assumptions about rate of usage are made. This is the subject of the activity, GROWING TIME.

Planet Earth: Some Measured Limits

Dimension	Approximate Value		Official Value	
	Metric	English	Metric	English
Radius	6,400 km	4,000 mi.	6,378 km	3,963 mi.
Circumference	40,000 km	25,000 mi.	40,076 km	24,902 mi.
Avg. ocean depth	4.3 km	2.7 mi.	4,270 m	14,000 ft.
Marianas trench	11.0 km	6.9 mi.	11,040 m	36,198 ft.
Deepest borehole, Oklahoma, 1974	9.6 km	6.0 mi.	9,590 m	31,441 ft.
Mt. Everest	8.9 km	5.5 mi.	8,854 m	29,028 ft.
Mt. McKinley	6.2 km	3.8 mi.	6,198 m	20,320 ft.
Surface area*	5.1×10^8 km^2	2.0×10^8 mi.^{2}	511,187,100 km^2	196,940,400 mi.^{2}
Land surface area*	1.5×10^8 km^2	0.6×10^8 mi.^{2}	148,678,000 km^2	57,280,000 mi.^{2}
Ocean surface area*	3.6×10^8 km^2	1.4×10^8 mi.^{2}	362,508,600 km^2	139,660,400 mi.^{2}
Volume**	10.9×10^{11} km^3	2.7×10^{11} mi.^{3}		
U.S. land area	$.09 \times 10^8$ km^2	$.03 \times 10^8$ mi.^{2}	9,363,123 km^2	3,615,122 mi.^{2}
U.S. continental shelf	$.0004 \times 10^8$ km^2	$.0001 \times 10^8$ mi.^{2}	36,110 km^2	13,942 mi.^{2}

English units are from World Book Encyclopedia, 1978. The metric units are calculated on basis of the formula for a sphere. Surface area = π d^2, with d = 12,756 km.

**Volume has been calculated on the basis of approximate values for Earth's radius and formula for a sphere, $V = 4/3\ \pi r^3$.*



Squaring "On the Double"

Objective:

To model exponential growth or "doubling time."

Materials:

Sheets of graph paper with 1/4" or 5-6 mm squares.

At least four colored pencils or crayons or colored pens per student.

Watch with second hand or minute-timer.

Procedure:

Tell the students that you will give them one minute to color a square on their graph paper. Of course they don't need that much time, but give them a full minute anyway.

Then ask them to use another color on two squares during the next minute. Ask for a third color and four squares during the third minute. Keep a steady pace with no waiting time between minutes. Ask for eight squares during the fourth minute, etc. until there is no more room on the paper.

Table A

Minute	Number of Squares to Color		Total Colored
1	1	(2^0)	1
2	2	(2^1)	3
3	4	(2^2)	7
4	8	(2^3)	15
5	16	(2^4)	31
6	32	(2^5)	63
7	64	(2^6)	127
8	128	(2^7)	255
9	256	(2^8)	511
10	512	(2^9)	1023

Expected Results:

Depending on size of the squares on the original graph paper, students may be able to color in eight or nine doublings before running out of space. Note to students how easy (plenty of time) it was to color in the first six minutes worth of squares, but how hurried they were during the last minutes of coloring.

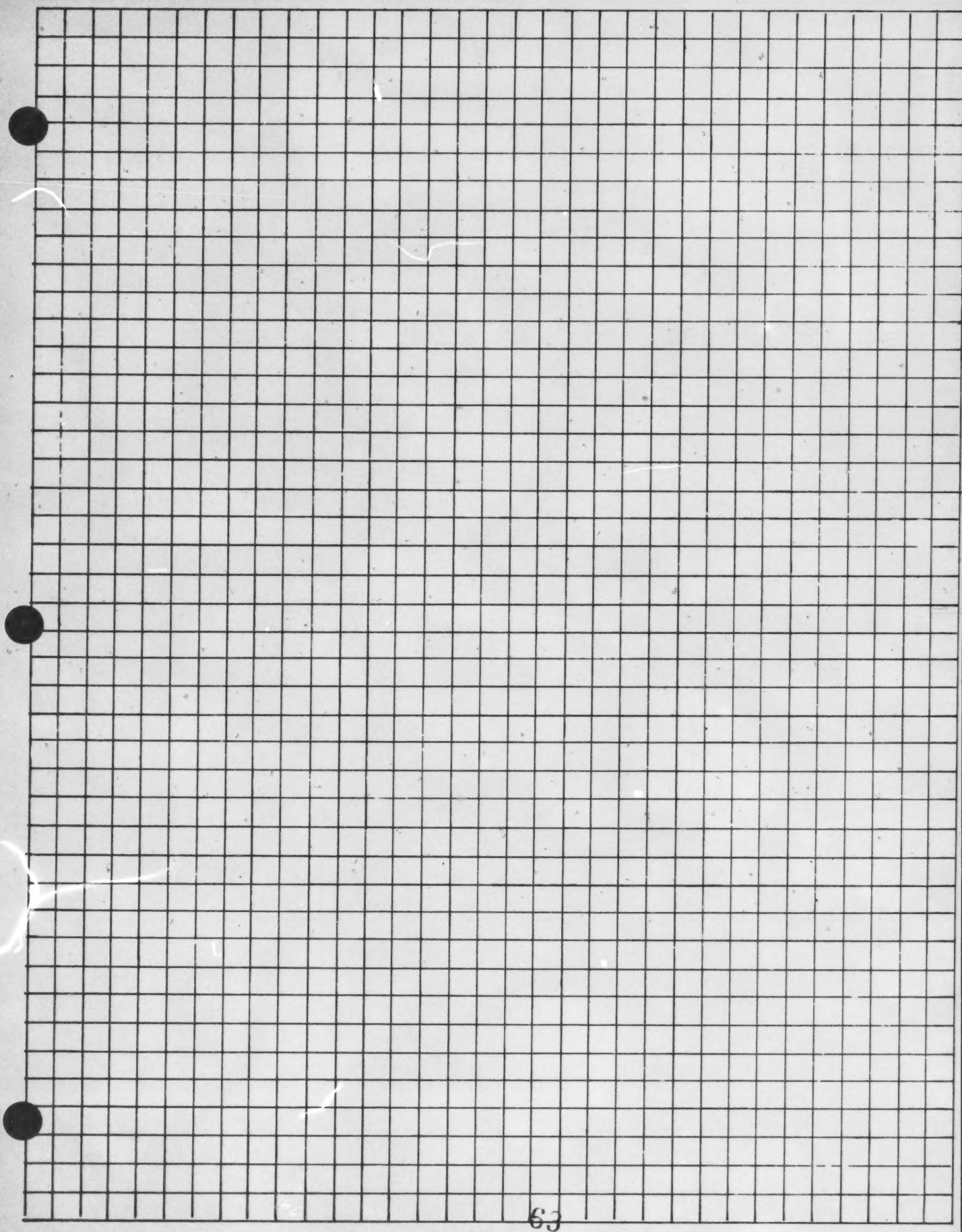
Questions:

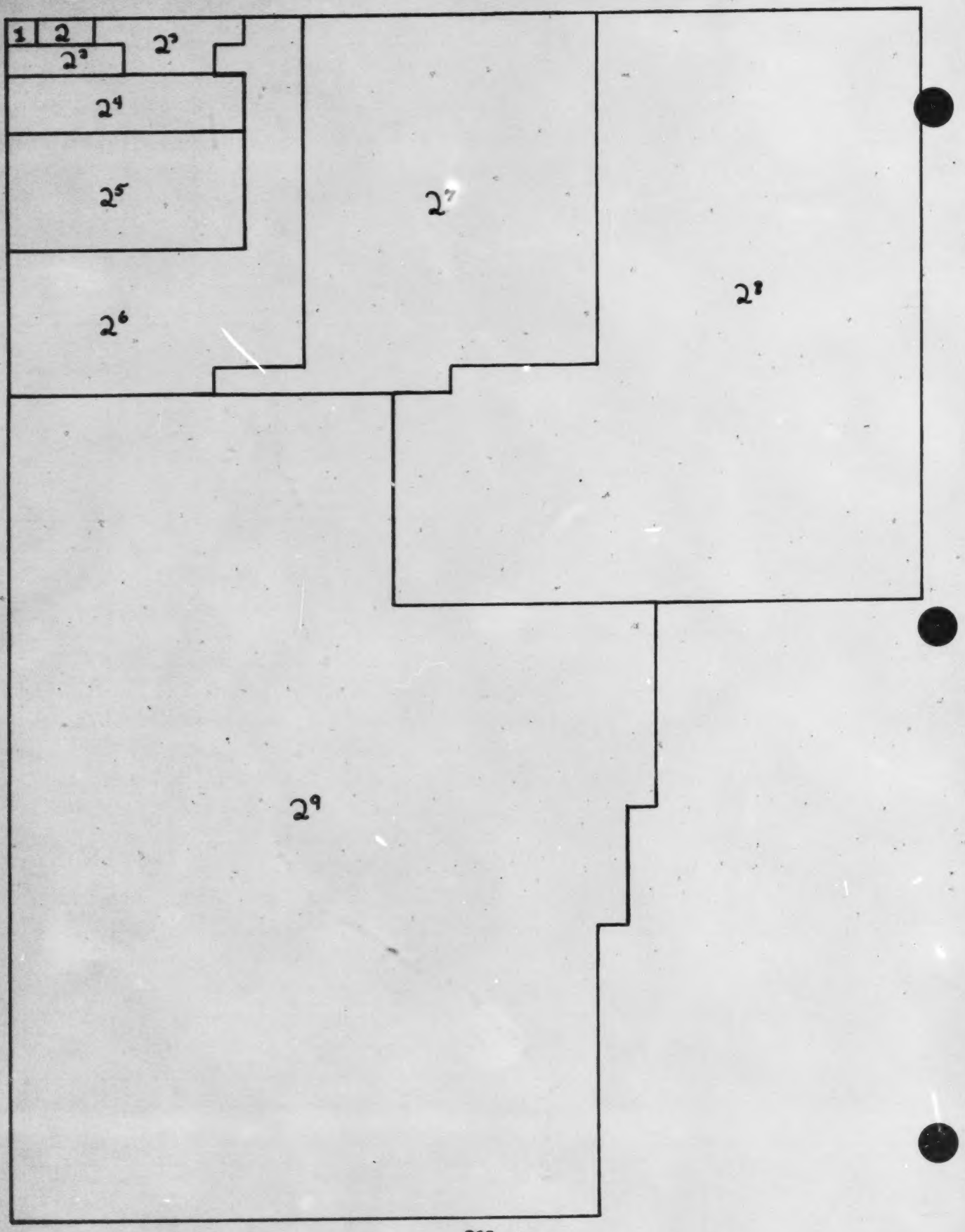
Ask what one would do in order to double the squares one more time. Get another sheet of paper?

Put Table A on the chalk board. Ask students to label their various colored areas with the exponent (power of 2) it represents. Draw attention to the fact that each successive doubling colors an area bigger than all the previous ones put together. This can be seen on Table A also . . . the previous "total colored" is always exceeded by the next doubling.

Now ask, "If we had continued to color only one square per minute instead of doubling every time, how much longer would the graph paper have lasted?"

The answer will be on the order of 1,200-1,500 minutes vs. the 8-10 minutes for the doubling pace (actual figures depend on the scale of the graph paper). Make the analogy to "steady-state" growth and/or use of resources vs. exponential growth or regular doubling of energy consumption, populations, human expectations of material goods.

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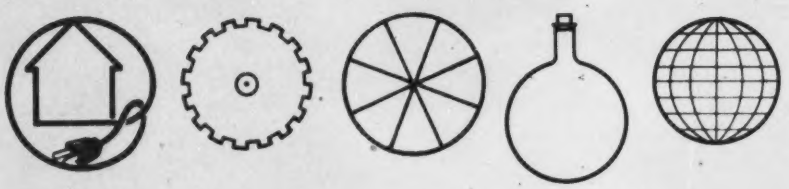


Blowing in Some Cents

The Story:

"A windmill's effect on its owner is powerful and seductive. All you have to do is buy it, raise it, point it toward the wind, switch on the lights, and relax--a quid free of the quo, jubilee!

"Well, it isn't that easy. I heat my house with oil and cook with gas. My lights, television set and stereo, well pump, refrigerator, freezer, washer and dryer, a few power tools--these cost me slightly more or less than 700 kilowatt-hours per month. But to obtain the same amount of energy through wind power, assuming a windy enough location, would require a capital investment of $16,500."

--Geoffrey Wolff, Quest/78

Some Facts:

As of January 1, 1979, customers of New York's Consolidated Edison were paying $62.06 a month for 750 kwh of electricity. Hawaiians were charged $62.51 for the same amount. Washington Water Power Company (State of Washington) was charging least of all investor-owned power companies in the United States: $12.20 for 750 kwh of power. In Iowa, customers of Iowa-Illinois Gas and Electric paid $40.69 a month for this rate of use.

Falling water is a cheaper power source than fossil fuels. (Nuclear can be considered "fossil" in the literal sense of the root word, meaning "dug up."). But can windpower match the delivered cost of New York's electricity if Mr. Wolff's figures for installation of a windmill are correct?

Questions:

1. If Mr. Wolff lives in the state of New York, what does he pay per month for 750 kwh of electricity (at January 1, 1979 rate)? _____

2. How much is this per year? _____

3. Let your answer in question 2 represent the savings from use of a windmill that Mr. Wolff could expect in 1979. If he paid cash for his windmill, what percent of return on his capital does this represent?

   ($ saved _____ ÷ $ invested _____) x 100% = _____

4. At this rate of return, how many years will he need to recoup his initial investment?

   Use the formula $\frac{70}{\%\ \text{return}}$ = years

5. If he does not buy a windmill, Mr. Wolff can invest his $16,500 at 9-10% in a special account at his local bank. Assuming his money earns only 9% simple interest, does it earn enough to pay his electric bills?

6. Based on your answers above, do you think that Mr. Wolff's decision was based on family economics?

7. What factors might change Wolff's decision?

8. What would be the advantages to owning your own windmill?

9. What would be the disadvantages?

Teacher's Guide to Blowing in Some Cents

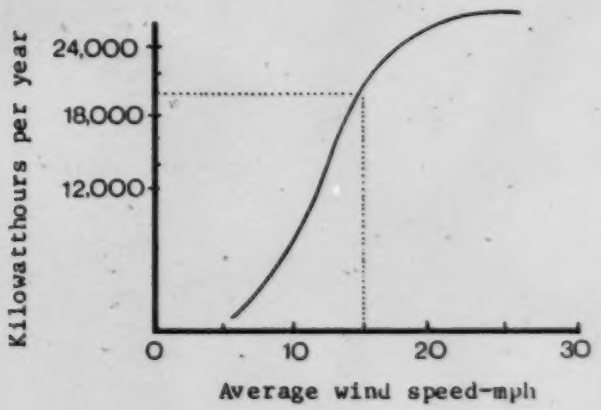
Although the energy source for a wind machine, moving air, is free, the equipment to convert that energy to useable form can be expensive. There are a number of methods for determining the cost of using wind. One is to estimate the cost of electrical generation by windmill using the following formula:

$$\$/kwh = \frac{(\text{capital cost})\ (\text{annual charge rate})}{\text{annual kwh production}}$$

The capital cost includes all expenses of the windmill including construction, delivery, and installation. This may be reduced by any available incentives such as the federal income tax credit.

The annual charge rate represents the interest, depreciation, taxes, operation, and maintenance as a percent of the capital cost. Although this varies widely with local circumstances, the American Wind Energy Association considers 18% as a typical annual charge.

The annual kilowatt hour production will vary from machine to machine and from site to site. However, manufacturers and distributors can usually provide a simple graph such as the one included here.



This graph can be used to make a gross estimate of the power that will be produced annually at various wind speeds. For example, if the machine represented by the graph were purchased for $16,000 completely installed, the cost of electrical generation at a site with 15 mph winds would be:

$$\$/kwh = \frac{(\$16{,}000)\ (.18)}{20{,}000} = \$.144 \text{ or } 14.4 \text{ cents/kwh}$$

If this windmill were in New York in 1979, its electrical generation at 14.4 cents/kwh is more expensive than the 8.3 cents/kwh charged by Consolidated Edison. However, commercial utility costs have increased rapidly and are likely to do so in the future. It is not possible to predict what average commercial cost/kwh will be over the life of the windmill. The cost/benefit ratio may change.

Also, this type of windmill is the most expensive kind. Windmills to pump irrigation water, or to warm water (see article in YE OLDE TIMES, SUN PRESS, and STAR GAZETTE included in this handbook), cost much less--$3,000 is the current quote for a conventional pumper--and are more likely to yield immediate economic benefits.

Answers Expected:

1. $62.06

2. $744.72

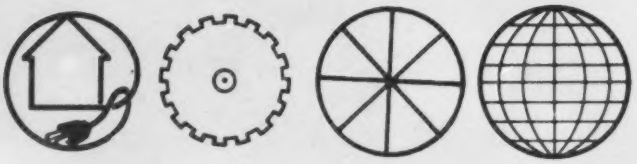
3. 4.5%

4. About 15.6 years

5. Yes, with dollars to spare. At 9%, his capital earns $1,485 vs. $744.72 in electric bills.

6. Yes, because the investment in a windmill shows a low return by today's standards.

7. Higher utility bills, lower earnings on his capital, lack of commercial electricity at any price, environmental threats by conventional power generation, desire for greater self-sufficiency, etc.



Energy in Manufacturing--II

Nearly all common materials require some processing before they are ready for use in standard form. Processing requires energy. Finished products that can be reused many times (or used over a long period of time) make more efficient use of this "energy of formation" than do those whose useful life is very short.

Paperboard, for one example, costs more than 100 times as much energy to manufacture, pound for pound, as does wood. (See chart following, Amount of Energy Required to Process Some Common Materials.) More boxes per ton can be made of paperboard, however, and less human labor is required to finish them than to put together wooden ones. Still, if each kind of box is used only once (as fruit crates are), paperboard cartons cost more energy than wooden ones. Polystyrene baskets (for berries, tomatoes) cost even more energy to make, petroleum itself being the basic stock for its chemical make-up. (See the same chart.) Can you see why some plastic containers may be the "collectibles" or antiques of the future?

Another factor to consider in calculating energy expense for materials is time of their useful lives. How long will this material last in finished form? Compare a pound of paper plates to a ceramic one or a pair of plastic ones. What is the useful life of the several paper ones vs. one ceramic one? vs. two plastic ones? To carry the energy cost analysis further, estimate how much energy will be required for maintenance of the glass and the plastic plates vs. how much energy will be required for disposal of the paper ones over the same time span. The high energy cost of a throw-away society should become obvious.

If you are clothes-conscious, then polyster, acetate, acrylic, and spandex may be familiar words. These fibers are all made from chemicals derived from fossil fuels. Much of the twenty-five billion square yards of fabric produced in the U.S. annually is based on these synthetic fibers which are very energy-expensive compared to cotton and wool. Do they provide longer wearing life to justify their higher initial energy investment? Or are they also luxuries of the Hydrocarbon Age that will become relics of 20th Century America?

Suggested Activity:

1. Have students use mail-order catalogs, and hardware and plumbing suppliers' ads, or have them phone local businesses to get the following prices:

   a. fiberboard shelves, chests, or room dividers vs. wooden ones;

   b. polyester shirts vs. all cotton shirts;

   c. copper vs. plastic pipe;

   d. paper, glass, and plastic plates;

   e. plastic vs. wooden toothpicks;

   f. plastic vs. straw brooms;

   g. steel, aluminum, and copper wire.

2. Estimate the length of useful life for each of the above items and compare it to cost . . . how many dollars/year is it likely to cost?

3. Check the energy investment each item represents on the chart. Did the more expensive items require more fossil fuel input to process their basic material? If not, why are they relatively expensive? Which items on your list would you expect to become most expensive as fuel prices rise?

4. Look at the chart again. When expensive energy becomes a way of life, which industries may have the most difficult time keeping costs down? (Keep in mind that the weight of the product is related to the energy cost on this chart. Miniaturization, where possible, is a viable strategy.)

Amount of Energy Required to
Process Some Common Materials

Material	Energy Input BTU x 10^6/ton
Crushed stone	0.1
Wood	0.3
Brick	6.9
Cement	12.4
Flat glass	18.1
Iron casting	25.0
Lead	31.1
Paperboard	36.4
Paper	40.6
Steel casting	46.7
Steel: carbon, cold-rolled	52.7
Aluminum: rolled, forged, cast	75.0
Zinc: rolled	79.2
Copper: wire	106.2
Copper: rolled	128.0
Nickel	374.7
Tin	469.3
Polystyrene (a plastic)	22,600.0

Data for this table is from Patterns of Energy Consumption in the United States, U.S. Office of Science and Technology, January 1972.

Energy Opinions and Priorities

Background:

In an article for Saturday Review (February 9, 1974), Walter Terry wrote:

> The world, including rich America, is desperate about its natural resources, about oil, gas, and indeed all the fuels that make it possible for us to live the way we want to live . . . . Our priorities? I read not long ago that the French, during their heating crisis, gave first priority to bakeries (French without their bread? Mon Dieu!) and second to old people's institutions.

What are some ways that people in your community are responding to the energy crisis? Are more people wearing sweaters in buildings and homes during the winter months than they did a year ago? two years ago? five years ago? In what ways have people been directly affected by the energy crisis? What are their expectations about the duration and seriousness of the crisis? What energy options do people living in your community prefer?

These kinds of questions can be answered by a survey. An example of such a survey is included in this activity.

Directions:

It is almost always difficult using a "canned" survey. The fit is never quite right. You may not be interested in the questions. Local issues may suggest the need for other questions. There may be no real need to ask the questions supplied.

If the questions in this survey match your needs you may want to use them as is. If not, they may be useful in helping you develop your own questions.

The questionnaire does not have to be used in the community. You can use it with a class, several classes, teachers or parents as well as community persons. This is a decision which you and the class are in the best position to decide. Pick a group or several groups and ask some questions you are interested in on the energy crunch.

An activity from Minnesota Environmental Sciences Foundation, "The Hyrocarbon Civilization," 1975.

After the survey, summarize the information. Calculate percentages if you find it useful. Compare responses if you used several audiences. Many of the questions in this survey were asked by the National Opinion Research Center in 1974. You may want to compare your results with theirs. This information is summarized in the magazine Science (April 19, 1974, pp. 257-263.)

Discussion:

1. What do you like best about surveys? least? What are some of the advantages of using surveys? disadvantages?

2. What have you learned about energy that is important to you?

3. What have you learned about attitudes toward energy questions? Were you surprised? Do you think the answers to these questions might be the same after the winter season? (TRY IT!) What would be the advantage of conducting this survey twice?

4. Is there any evidence that energy events featured in the press and radio/television affected the results of your survey? How could you test this?

An Energy Opinionnaire

____ 1. Who has major responsibility for the energy crisis?
- a. Federal government
  - (1) Congress
  - (2) Administration
- b. Oil companies
- c. Environmentalists
- d. Organization of Petroleum Exporting Countries (OPEC)
- e. Individual consumers

2. Do you expect to have difficulty obtaining any of the energy sources listed below within the next 12 months?

____ Gasoline
____ Home heating fuel
____ Electricity
____ Recreational vehicle fuel

____ 3. a. Can the gasoline shortage be temporarily solved by consumers using less gasoline?
- b. Have you voluntarily used less gasoline in the past 12 months?

____ 4. If there is not enough fuel for everyone, which uses do you think are most important? (Rank 1 through 8.)
____ a. Heating homes
____ b. Farming operations
____ c. Factory operations
____ d. Business driving by private citizens
____ e. Pleasure driving by private citizens
____ f. National defense
____ g. Commercial freight transportation
____ h. Mass transit

5. If motor fuel must be rationed, which vehicles should get it first? (Rank order the choices.)
____ a. Farm vehicles
____ b. Private cars
____ c. Urban mass transit
____ d. Trucks
____ e. Railroad freight trains
____ f. Buses - between city trips
____ g. Commercial airlines
____ h. Passenger trains - between city trips
____ i. Private airplanes
____ j. Taxis
____ k. Construction vehicles

____ . By what year do you think we will have all the energy we need?

. In the past year have you

____ a. Reduced daytime heating temperatures?
____ b. Attempted to cut electricity use?
____ c. Changed to lower bulb wattages in hallways?
____ d. Reduced clothes dryer use?
____ e. Had trouble obtaining gasoline?
____ f. Had trouble obtaining electricity?
____ g. Changed mode of travel to school or work?

____ 8. Do you believe that a technological energy miracle will save us? What do you think it might be?

_____

9. How seriously do you expect to be affected by the energy shortage in:

	not seriously	somewhat seriously	seriously	very seriously
a. 6 months	)	)	)	)
b. 1 year	)	)	)	)
c. 5 years	)	)	)	)
d. 10 years	)	)	)	)

____ 10. Is gasoline rationing necessary?

11. If gasoline rationing is necessary, do you think that

____ a. People living in areas with little or no public transportation should get extra ration coupons?
____ b. People using their cars for business should get extra ration coupons?
____ c. Ration coupons should expire at the end of 12 months?

12. If you could ask one energy question of a person in government, industry, education, etc., what would it be? _____

_____

_____

To whom would you direct this question?

_____

____ 13. a. Is energy the most important issue facing this nation today?
b. If your answer to 13a is "No," what do you think is the most important issue facing this nation today? _____

_____

Teacher's Guide to Energy Opinions and Priorities

Encourage students to clip articles from magazines or newspapers that report results of national surveys on energy questions. Whenever the class expresses doubt that the consensus reported reflects their own opinions, you have an indication of questions that would be appropriate for students to use in making their own surveys.

In April, 1979, a majority of Americans still did not believe that energy shortages were real according to an Associated Press-NBC News survey. In fact, more respondents in 1979 believed that energy crises were a hoax than did those surveyed in 1978. (See chart below).

AP-NBC News Survey

Date	Energy Crisis is Real	Energy Crisis is Hoax	Undecided
Aug. 1978	46%	46%	8%
Apr. 1979	37%	54%	9%

News of excess profits by oil companies, of trouble at Three Mile Island nuclear plant, and a speech by President Carter emphasizing the unpleasant reality of energy shortages immediately preceded the poll-taking in 1979. The summer of 1978 was relatively non-eventful in energy matters.

Another aspect of this widely-reported poll of 1,600 adults by AP-NBC News showed a preference for solar energy in the future over all other forms. Fifty-two percent of the respondents favored solar energy; 21% favored coal; 16% preferred nuclear; 4% chose oil; and 7% were undecided. Also 56% of those interviewed were more worried about getting enough energy than they were about paying for it. Thirty-eight percent said they were more worried about the bill for utilities than about the energy supplies. Six percent were not sure. But, on another question, only 14% would agree to pay an extra $11 to $25 a month to finance a switch to solar energy. The split between people's opinions, and willingness to act on those opinions, is noteworthy.

How Now, Dry Cow!

Bringing food to our table means using energy over and over again. How much energy is consumed in producing and delivering any one commodity varies greatly. Each step in the processing chain costs energy, and as the cost of energy has grown to be appreciable, that expense is becoming reflected in grocery store prices.

The energy in an essential food like milk came from the sun. It stimulated the growth of plant fodder for the cow who transformed and concentrated some of that stored energy into milk. Getting that milk from the cow to your kitchen usually involves much more energy, amounts depending on the route followed.

Milk can be bought in several forms. Fresh milk is usually packaged in waxed paper cartons or in plastic jugs. Evaporated milk is offered in cans. Dried skim milk is usually packaged in foil-lined paper boxes. How much does each of these types of container hold? How many containers are necessary per gallon of milk? Which kinds "cost" the most energy? (See the accompanying chart: Amount of Energy Required to Process Some Common Materials)

Processing each form of milk (fresh, evaporated, dried) requires energy. All milk is pasteurized, a process requiring heat to kill dangerous bacteria. Evaporated milk is not only pasteurized but also is heated further until half of its water content is gone; then it is heat-sealed into cans. Drying milk to powder or granules also requires considerable energy, but the loss of water means loss of weight, so packaging and transportation costs are reduced. Loss of water also stops common bacteria from living on the milk, so energy-expensive storage (refrigeration) is unnecessary. Fresh milk must be refrigerated constantly.

Transportation of milk costs additional dollars and is often proportional to weight. As energy prices soar, the processing, packaging, storing, and transporting costs of marketing milk will also increase.

Activity:

Check prices of canned, fresh, and dried milk at your local grocery. Be sure to note unit size and weight as well as price. Fill in the following data table:

Milk Type	Price	Unit Size	Unit Weight	Equivivalent fluid volume	Price/ Gallon
fresh					
canned					
dry					

Questions:

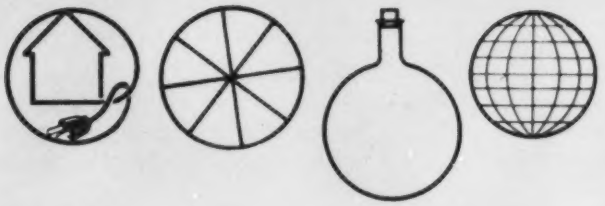
1. Which type of processed milk cost most?
2. What were the energy inputs contributing to this cost?
3. Which type of milk cost least?
4. Give at least one reason why this type is less expensive.
5. List an advantage and a disadvantage of each of the processed milks.
6. How could some of the energy consumed in processing milk be provided directly by the sun? Try to suggest at least one possibility.

**To bring canned milk to the equivalent of fresh, multiply by 2. To bring dried skim milk to the equivalent of fresh, multiply by 10. (4 lbs. dry milk + 36 lbs. water = 40 lbs. or 5 gallons of fluid milk.)*

Amount of Energy Required to Process Some Common Materials

Material	Energy Input, BTU x 10^6/ton
Crushed stone	0.1
Wood	0.3
Brick	6.9
Cement	12.4
Flat glass	18.1
Iron casting	25.0
Lead	31.1
Paperboard	36.4
Paper	40.6
Steel casting	46.7
Steel: carbon, cold-rolled	52.7
Aluminum: rolled, forged, cast	75.0
Zinc: rolled	79.2
Copper: wire	106.2
Copper: rolled	128.0
Nickel	374.7
Tin	469.3
Polystyrene (a plastic)	22,600.0

(Data for this table is from Patterns of Energy Consumption in the United States, U.S. Office of Science and Technology, January, 1972.)



Life Without Electricity
A Peace Corps Experience

Introduction:

After graduation from the University of Iowa, Jensy Patterson joined the Peace Corps in the summer of 1978. She was sent to Kenya, East Africa where she became one of four teachers staffing a 90-student Harambee high school. The rural village that is her home now lies in mountainous terrain near Lake Victoria and Kisii in western Kenya. The area has only two seasons, the rainy and the dry. Daytime temperatures do not change much throughout the year, but nights during the dry season can be chilly. Here are some of Jensy's comments on her new life without electricity, excerpts from a letter she wrote to a snowbound friend in Iowa:

The Letter:

Keroka, Kenya, January 22, 1979

For your own knowledge, I'll try to describe some of the energy uses here. Of course, there is no electricity. There is some in Kisii town which is about 12 miles away.

Everyone lives in small mud and thatched huts. The only permanent buildings around are the school and my house. Even the small dukas (shops) down the road are made of tin.

Firewood is commonly used if the dead wood can be found. (I came back one weekend to find many of my trees chopped down.) It's hard for these people on the top of the mountain and on the sides because the trees help prevent erosion, yet they need the wood for cooking and occasionally for warmth. They cook in their huts on the floor or in chiko--a small round metal container. It sits on the ground and is similar to our barbecue stoves. The old men in the market make them and sell them for about 15/= to 25/= ($2-$3).

December is also charcoal making month. All over the hills you can see smoke billowing. They chop the wood and cover it with dirt, leaving some small holes, and then light it to remove the impurities. After about 18 hours they have charcoal. This is sold for about 20/= ($ ____) for a large burlap bag. This is what is most commonly used in the chiko cookers. They use kerosene to light them. This is also used in their lanterns.

Candles are also used for light, but not often. (I do use them, but they are expensive here.) Kerosene costs about 11/= ($1.50) for five liters. I also use a pressure lamp which is about 600 candle power, but these are very expensive. Mine cost about 300/= ($43). I almost feel bad about having it, but figure the cost of my eyesight is worth a lot more than the impression these people will get of me having so many things.

A few, very few, wealthy people use a gas cooker. There are also pump stoves run on paraffin and some people use these, but I prefer the charcoal.

After awhile, all this becomes a way of life. I really enjoy not having electricity. Life is very simple without it. People usually go to bed early here too. 9:00 p.m. is "getting very late, madam!"

Kenyans depend on the sun for so much--time, drying clothes, crops. It seems the days are getting longer here too.

Of course there is no running water either. I'm the only one within several miles who has a rain tank. The school provided it, but it leaks and thus I too am dependent on the "river" (small stream actually) for my daily water needs. Because of my cooker I can warm my bath water but most either bathe in the river or out of a bucket; both are chilling experiences, believe me!

Because there are no street lights there is very little transport on the road after 6:30 - 7:00 p.m. The African's eyesight must not adapt too well to driving at night.

Torches (flashlights) are a part of every household. Batteries are very expensive. I have gone through so many. In physics I taught my kids that if you put the cells in the sun when they are weak, this exposure will repolarize them so that they can be used again. They were thrilled.

In all of Kenya there is only one "laundromat." It's in Nairobi and you can bet four of the six machines are always broken. Everyone does laundry by hand, then lays it on the grass to dry. I've learned to fold mine so they don't have too many wrinkles. There are charcoal irons though.

Of course, with no electricity there is no refrigeration. Many simply don't need it. My eggs last about three weeks and up on my hill my fresh butter will stay hard for two weeks. I'm extremely atypical though. No one else has the coolness I have.

There is milk in cartons I buy called UHT--it's ultra heated. Also margarine comes in a can and dried milk is popular. Many people enjoy the "sleeping milk" which is sour and curdled and kept in gourds. Kenyans think that the soured milk is very sweet and they simply can't understand why I don't like it. They use fresh milk only in tea.

Hope this gives you some picture of life without electricity. Cold sodas are unheard of as is beer. You get used to things!

As always,

Jensy

Teacher's Guide to Life Without Electricity: A Peace Corps Experience

There are many areas for discussion or for written question-and-answer responses suggested by this letter. Choose some that reflect your own interests and the subject matter of your course. Or ask a teacher from another discipline to participate in a wider ranging class discussion on ways and means of getting along on a low-energy budget.

Examples of questions you may use are:

1. What renewable sources of energy are mentioned in the letter?

   (Firewood and wood charcoal; sun; also students possibly may mention candles and gas which may be "renewable," depending on the raw material base for each. Candles can be made of beeswax or tallow, which are "renewable" or from paraffin, a non-renewable petroleum by-product. Natural gas, L.P. gas, or propane is associated with oil production from underground reservoirs and is not renewable. Methane or "biogas" from anaerobic digestion of organic wastes is renewable. In fact, the candles and gas to which Jensy refers are petroleum by-products and are therefore non-renewable.)

2. What non-renewable energy sources are mentioned in the letter?

   (Cooking gas, batteries, kerosene, paraffin, candles)

3. Which of the above energy sources did your grandparents use 40-50 years ago?

4. Which of the energy sources mentioned above do you use regularly now?

5. What do you think Jensy likes best about her low-energy-use situation?

6. What does she like least?

7. How has lack of electricity changed her living habits?

   (Note references to cooking and food storage; laundering; sleeping schedule; transportation.)

8. If you were to take Jensy's place in Kenya, what would present the greatest challenge to your present lifestyle?

9. What would be necessary for your survival in a remote Kenyan village? Would you have to take some articles from home with you?

10. Locate Kisii, Kenya on a map of Africa.

    What is its latitude? (0.5° S)
    What is its longitude? (nearly 35° E)
    What is its elevation? (high plateau, mountainous terrain, more than a mile high)

11. What does the above information tell you about insolation (incoming solar radiation) in that part of Africa?

    (Near the equator, solar insolation is maximum. The sun is directly overhead twice yearly and the lowest "winter" angle is comparable to the angle of the summer sun in Iowa. The high elevation means that the atmospheric blanket of air is thin. By day, less insolation is lost to atmospheric screening, but more heat is lost at night than would be true in the lowlands. Cool nights and snow on the highest peaks are possible.)

12. How does the local climate near Kisii moderate basic energy needs (compared to Iowa)?

    (Little additional heat is needed for keeping people warm. Well-sealed homes that need artificial heating and cooling are not necessary for survival. However, heat for purifying water and milk is even more important for good health than here because tropical microorganisms are very numerous. Long growing seasons make long-term food storage less important than in Iowa, but heat is necessary for some forms of preservation--including tea production. Less clothing is needed for personal warmth. Transportation vehicles, where available, run more efficiently in warm climates than in cold ones. Animals require less food to maintain body temperature and growth rate than they do in more variable climates. Trees grow faster so, if replanted, replace firewood faster. Daylight hours are never much longer nor much shorter than 12 hours so opportunities for evening activities are very limited unless some other source of light is available, even at the peak of summer.)

13. How much does a large bagful of charcoal cost in western Kenya?

    (On the first page of Jensy's letter it says charcoal costs 20/= ($___)
    Clues to the dollar equivalence are

    --that cookers cost 15/= to 25/= which is $2-$3.

    If 15/= is $2, than 1/= is $\frac{2.00}{15}$ or 13 cents

    If 25/= is $3, then 1/= is $\frac{25}{3.00}$ or 12 cents

--that kerosene costs 11/= or $1.50,

so 1/= is $\frac{1.50}{11}$ or 13 1/2 cents

--that her lamp cost 300/= or $43,

so 1/= is $\frac{43}{300}$ or 14 cents.

Using these figures, charcoal at 20/= cost $2.40 to $2.80 in U.S. dollars.

14. How is charcoal made in the U.S.?

15. What are the uses of charcoal in the U.S.?

16. Why is fresh milk heat-treated?

(Like "pasteurization," the term more common in U.S., ultra heat treatment destroys several kinds of disease-causing organisms without much change in the chemical composition of the milk. It also slows the natural fermentation of milk, so it tastes fresh longer.)

17. What are the energy-related advantages of dried milk?

(Extra heat is required to process dried milk. However, this "expense' is more than offset by great energy savings in refrigeration, packaging materials, and transportation costs in distributing milk. Removing the water reduces the weight of milk by 90% and the volume by 75%. No refrigeration is required until or unless the milk is remixed with water for drinking. If kept dry, the milk powder lasts for months.)

18. If wood and charcoal were the only fuels available, how might food preparation methods and daily menus be affected?

Some Energetic Figuring

Agriculture is a prime user of energy. However, its products, food and fiber, are also energy resources. To measure efficiency of the system in energy terms, the "net" production, one would have to know both input and output levels in terms of calories, joules, BTU's, or kilowatt hours. Such statistics have not been part of traditional record keeping, but are being compiled now that their importance is recognized. The Iowa Crop and Livestock Reporting Service compiled data on energy use on Iowa farms that is included in the 1975 Iowa Farm Fuel and Equipment Survey. The figures cited below come from that publication.

1.

Complete this chart by making the necessary calculations.

Direct Fuel Use on Iowa Farms
1975

Type of Fuel	Millions of Gallons Used	% of Total
gasoline	375	_____
L.P. gas	212	_____
diesel	149	_____
fuel oil	54	_____
Total:	_____	_____

2.

Twenty-three percent (23%) of the gasoline used on farms, 47% of the L.P. gas, 2% of the diesel fuel, and 93% of the fuel oil was used for personal transportation and/or home heating. The balance of fuels mentioned above were consumed in agribusiness. Figure how many gallons of fuel were used for farm production in Iowa in 1975.

a. First calculate the number of gallons of fuels listed consumed for "personal" use. Use the chart provided.

b. Then subtract the amount calculated for personal use (in "a") from the total (in problem 1) to determine the amount consumed for agricultural business.

Type of Fuel	Millions of Gallons Used: Total (Problem 1)	Millions of Gallons for Personal Use ("a")	Millions of Gallons for Agribusiness ("b")
gasoline			
L.P. gas			
diesel			
fuel oil			
Total:			

3.

Electric usage on Iowa farms totaled 2,223 million kilowatt hours in 1975. Over half of this amount (52% was for general farm use and nearly one quarter (23%) for livestock production. Smaller amounts were used for crop production (8%), home heating (7%), and dairy production (6%).

a. How many kilowatt-hours were used in agricultural practices in 1975 in Iowa?

b. How many kilowatt-hours were unaccounted for?

c. Another way to express energy per unit of time is in joules. One kilowatt-hour is equivalent to 3.6×10^6 Joules. How many joules of electric power were used for agriculture in Iowa in 1975? (Use answer 3a.)

d. Since an energy source with an original output of about 3.1 joules is required to produce each joule of electricity, how much energy was put into the generating system in order to produce this much electricity? (Use answer 3c).

e. A barrel of oil has a typical energy content of 5.8×10^9 joules. What is the "oil equivalent" consumption necessary to yield the energy total you calculated in 3d?

4.

There are approximately 42 U.S. gallons of oil in a barrel. How many barrels of oil were consumed directly for production on Iowa farms? Use data from Problem 2.

5.

Total the "oil equivalent" energy sums from problem 3e, and 4. How does this compare with the country wide figure of 340 million barrels of oil used in food production?

$$\frac{\text{Iowa's use}}{\text{U.S. use}} \times 100 = \%\text{ of U.S. food production energy consumed in Iowa}$$

6.

Authorities estimate that U.S. farms used the equivalent of 340 million barrels of oil for food production in 1976. This is 2.5% of the total annual U.S. energy budget. Calculate the number of barrels of oil on which these figures are based. (Clue: 340,000,000 is 2.5% of ?)

Teacher's Guide to Some Energetic Figuring

Objectives:

Familiarize students with some basic energy accounting, energy units, and using powers of 10.

Recommended additional activities:

See Agriculture, Energy, and Society prepared by NSTA for U.S. DOE, 1978.

1.

Note that the figures represent millions of gallons.

Direct Fuel Use on Iowa Farms
1975

Type of Fuel	Millions of Gallons Used	% of Total
gasoline	375	47
L.P. gas	212	27
diesel	149	19
fuel oil	54	7
Total:	790×10^6*	100%

2.

Type of Fuel	Millions of Gallons Used: Total (Problem 1)	Millions of Gallons for Personal Use ("a")	Millions of Gallons for Agribusiness ("b")
gasoline	375	86	289
L.P. gas	212	100	112
diesel	149	3	146
fuel oil	54	50	4
Totals:	790×10^6	239×10^6	551×10^6

**Total direct fuel use on Iowa farms in 1975 was actually a little higher than these figures show. Some farms (about 4%) used natural gas for home heating and a few used coal or wood.*

3.

a. Agricultural use is 52% + 23% + 8% + 6% or 89%. 89% x 2,223 million kwh = 1,978.47 x 10^6 kwh. (For convenience, you may wish to "round off" to 1,978 or even 1,980.)

b. 89% ag use + 7% for home heating = 96% accounted for; 4% "unlisted." 4% x 2,223 million = 88.92 or 89 x 10^6 kwh unaccounted for.

c. $3.6 \times 10^6 \times 1{,}978 \times 10^6 = 7{,}121 \times 10^{12} = 7.1 \times 10^{15}$ joules

d. $7.1 \times 10^{15} \times 3.1 = 22.01 \times 10^{15} = 2.2 \times 10^{16}$ joules

e. $\frac{2.2 \times 10^{16}}{5.8 \times 10^9} = .38 \times 10^7$ bbl.

or

3.8×10^6 bbl.

4.

$$\frac{551 \times 10^6 \text{ gal.}}{42 \text{ gal/bbl.}} = 13.1 \times 10^6 \text{ bbl.}$$

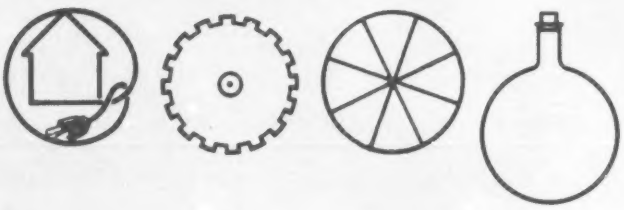
5.

$13.1 \times 10^6 + 3.8 \times 10^6 = 16.9 \times 10^6$ bbl. (Iowa)

$$\frac{16.9 \times 10^6 \text{ bbl. Iowa}}{340 \times 10^6 \text{ bbl. U.S.}} = .0497 \times 100\% = 5\%$$

6.

$340 \times 10^6 \div .025 = 13{,}600 \times 10^6 = 13.6 \times 10^9$ or 13.6 billion bbl.



Cabin Fever I

Surface Area

Introduction:

Heat naturally travels from a warmer place to a cooler one, or from an energy "source" to an energy "sink." How quickly that transfer happens depends on many factors. In the case of buildings that need heating or cooling, some of the considerations are:

How much surface area is conducting heat? (CABIN FEVER I)
How well insulated is it? (CABIN FEVER II)
How tightly sealed is it? (CABIN FEVER III)
What does the site and its plantings contribute to the energy flows? (CABIN FEVER IV)
What are the activities of its occupants? (CABIN FEVER V)

Surface area or "skin" of a building varies with its design. The more exposed "skin," the greater is the potential for heat transfers. However, the smallest house is not necessarily the most efficient. For many designs, small increases in linear dimensions yield larger increases in volume. Even for homes or apartments of the same floor area or living space, their general shape and arrangement makes some more efficient than others. In general, the larger the volume of inside air to the outer surface areas of floor, walls, and roof, the slower the rate of total heat exchange between the inside and the outside.

Background:

In order to consider the amount of surface area conducting heat, we need to calculate floor area, volume, surface area, and the ratio of volume to surface area. Let's consider each of these factors in turn.

a. Floor area is length times width on the rectangular plans, with 8 ft. being the height of each unit. The "L" plan is best calculated in sections. The "A" frame has a standard rectangular base, 30 ft. x 35 ft. The dome has a circular floor for which the area is πr^2 or 3.14 x 18 ft. x 18 ft.

b. Volume involves all three dimensions, length x width x height. Again, the "L" is best considered as the sum of each rectangular section. The A-frame is 1/2 of the cracker box (rectangular solid), or area of the triangle times length. The dome is 1/2 of a sphere so its volume would be 1/2 ($4/3 \pi r^3$).

c. Surface area includes all wall, floor, and ceiling areas.

For the "ranch," for example, you have both a floor and a ceiling 24 ft. x 43 ft.; there are two walls 24 ft. x 8 ft. and two walls 43 ft x 8 ft. So total surface area is:

$$\begin{aligned} 2 \times 24 \times 43 &= _____ \\ +\ 2 \times 24 \times 8 &= _____ \\ +\ 2 \times 43 \times 8 &= _____ \end{aligned}$$

Total: _____ sq. ft.

Some formulae to recall: Area of a triangle is 1/2 altitude times the base. Area of a circle is πr^2. Surface area of a hemisphere is 1/2 πd^2.

d. A ratio is a comparison between two figures. In comparing the volume of air enclosed to the outer surface area where exchanges of heat take place, we are assuming that air escapes the way people leave a supermarket, taking the shortest "line" out. If the number of check-out counters varies from market to market, the same volume of customers will be served faster in some stores than others. Similarly, if the surface area figure is close to that for volume, the ratio will be a small number (fast exchange, "short line" at the check-out). If the surface area is limited compared to the volume, the ratio will be a larger number (slower exchange, "longer line" at the check-out).

Because interior air has been deliberately heated or cooled at some energy cost, slowing down its exchange is desirable. Designs that provide a minimum exterior surface in relation to interior air space (higher ratio) are likely to require less energy for space heating and air conditioning than designs having a low ratio. This assumes that the buildings being compared are alike in materials, construction, insulation, window area, occupants and other energy-use related factors.

Directions:

With this in mind, compare the heat retaining advantages of various shapes for some modest homes. Using the dimensions given on the following chart, do the calculations necessary to complete it.

After you have completed the chart, answer the following questions.

1. How similar are these houses/apartments in functional living area?

   a. What is the average floor area of each living unit. Assume for the sake of your calculations that the 2-Story Square is a duplex (first calculate its average floor area). Make the same type of calculation for the 4-Unit Apartments.

b. Which house plan shows the largest difference (plus or minus) from the average floor area?

c. Using your calculations in 1b, determine the largest percent of difference from the average floor area.

$$\frac{\text{Largest Difference in Floor Area}}{\text{Average Floor Area}} \times 100 =$$

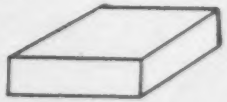
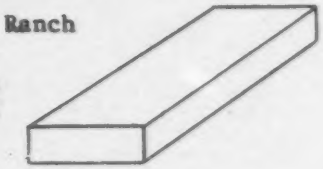
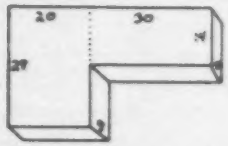
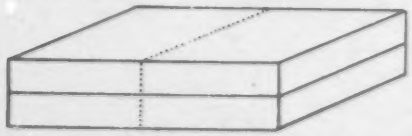
2. Which design has the best potential for slowing down heat losses?

3. Which design would be easiest to insulate? Describe how you would do it.

4. Can you suggest another design that would be better in slowing heat transfers?

Name _____

Student Worksheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area ($ft.^2$)	b. Volume ($ft.^3$) (to heat & cool)	c. Surface Area ($ft.^2$)	d. Ratio Volume/ Surface Area
Square 	32 x 32 x 8				
Ranch 	24 x 43 x 8				
Small "L" 	20 x 28 x 8 and 30 x 14 x 8				
2-Story Square	32 x 32 x 16				
4-Unit Apartments 	64 x 32 x 16				

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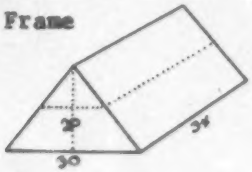
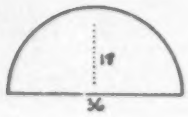
Name _____

Student Worksheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area ($ft.^2$)	b. Volume ($ft.^3$) (to heat & cool)	c. Surface Area ($ft.^2$)	d. Ratio Volume/ Surface Area
"A" Frame 	30 x 34 x 20 ft. peak				
Dome 	36 ft. = diameter, 18 ft. = radius				

1. a. _____
   b. _____
   c. _____
2. _____
3. _____
4. _____

250

Teacher's Answer Sheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area ($ft.^2$)	b. Volume ($ft.^3$) (to heat & cool)	c. Surface Area ($ft.^2$)	d. Ratio Volume/ Surface Area
Square	32 x 32 x 8	1,024	8,192	3,072	2.67
Ranch	24 x 43 x 8	1,032	8,256	3,136	2.63
Small "L"	20 x 28 x 8 and 30 x 14 x 8	980	7,840	3,208	2.44
2-Story Square	32 x 32 x 16	2,048	16,384	4,096	4.0
4-Unit Apartments	64 x 32 x 16	4,096	32,768	7,168*	4.57

Teacher's Answer Sheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area ($ft.^2$)	b. Volume ($ft.^3$) (to heat & cool)	c. Surface Area ($ft.^2$)	d. Ratio Volume/ Surface Area
"A" Frame	30 x 34 x 20 ft. peak	1,020 + loft	10,200	3,320	3.07
Dome	36 ft. = diameter 18 ft. = radius	1,017.4 + loft possible	12,208.3	2,034.7	6.00

252

1. a. Average floor area/living unit + 1,017.3 $ft.^2$

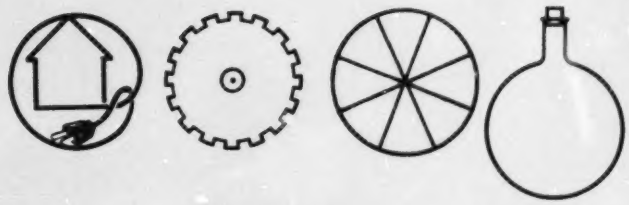
   b. Small "L" house shape

   c. 3.6%

2. In terms of potential, the dome is best due to less escape routes for heat transfer.

3. There is no one right answer. Ease of insulation depends upon local limitations on construction, materials, installation expertise, costs, and time.

4. A number of valid suggestions may be proposed including berming, double wall or envelope construction, underground homes, row housing with shared walls, windowless north walls, etc.



Cabin Fever II

Insulation

The second factor affecting how fast heat transfers in or out of a building is the materials of which that building is constructed in the first place. The exterior surface or "weatherskin" transfers heat into or out of the house at a rate that varies with the kinds and thickness of materials incorporated into the walls.

Every building material has its individual insulation value. It can be expressed as U, coefficient of heat transfer (BTU/hr/ft^2/°F), or the resistance to heat flow (R). These values are reciprocal: $U = \frac{1}{R}$. The higher the "R-value," the better the resistance to heat loss. R-values are additive--thicker material or a combination of materials usually means increased insulating value.

Typical Heat Resistance (R-Value) of
One Inch of Various Materials

Material	R/inch
polyurethane foam	6.25
shredded newspaper	5.50
polystyrene board	5.26
cellulose (loose)	3.70
fiberglass (batt)	3.17
perlite	2.70
rock wool	2.20
softwood (fir, pine)	1.25
air space	0.91
dry snow	0.80
light, dry soil	0.40
plaster	0.18
heavy soil, damp	0.09
concrete	0.08
average rock	0.06

Source: ASHRAE Handbook of Fundamentals and J. Scalise, Earth-Integrated Architecture.

Amount of air spaces or pockets separating the solid parts in the material is a second important determinant of its ability to slow heat conduction. The more air spaces and the lower the conductivity of the solid between them, the better the insulation value. So it should not be surprising to find that popcorn and shredded newspapers are good insulators. (A large air space is not a good insulator because convection currents develop which assist heat flow.)

Reflective metal coatings can also act as effective barriers against heat loss. Aluminum, chrome, silver, or other shiny surfaces reflect long-wave (heat) radiation. Adhesive metallic films for windows are comming into use, making "heat mirrors" of these openings without blocking an insider's view. If this foil has an air space in front of it, it can reflect up to 95% of the heat energy before the heat is absorbed by the insulation or glass and conducted outward. Architect David Wright reports that a 1/4 inch airspace, when lined with foil, attains an R-value of 2.5.

R-value alone is not the criteria for selecting building materials or added insulation. Fire-resistance, structural qualities, pest control, space availability, cost-effectiveness, ease of installation, and energy required for production and delivery are some of the other factors to be considered in determining the best choice for a particular building and location.

Since heat rises, the ceiling is the most important part of buildings to insulate well. It keeps more heat in the room and slows its escape upward. This stabilization then reduces the air exchange rate and the pulling in of colder outdoor air. The furnace will run less, the interior will be more comfortable, and energy savings can be expected.

Well-insulated walls and floors are also very important, however. In order to get "thermal balance" or even heat throughout a home, new dwellings designed for energy efficiency use more insulation in exterior walls. 2" x 6" studs permit thicker walls and more insullation in conventional construction. "Arkansas Plan" houses built with 6" wall and 12" ceiling insulation (R-19 and R-38) have been using one-third the heating and cooling dollars of standard new homes.

Suggestions for Student Activities:

1. The Iowa Extension Service in Ames and many local utility companies provide an "energy audit" service. Call or write for audit forms on which students list basic features of their homes, apartments, or school: number of windows, length of exterior walls, floor areas, style and number of exterior doors, etc. Counting and measuring can be done by junior high students; only basic math skills are required. Send the forms back to the sponsor for a computer-assisted analysis of likely places that changes in the building or in the activities of its occupants may save energy, or consider doing the economic analysis with the help of a detailed, step-by-step instructional booklet, "In the Bank or Up the Chimney." Published by HUD, this resource is available for $1.70 from the Sup't. of Documents, Government Printing Office, Washington, DC 20402. Ask for # 023-000-00297-3.

2. Use several identical packing boxes as "model houses." Put a thermometer inside each in such a way that it can easily be read without disturbing the box. Make a small window, of the same size and material for each box. Put a second thermometer on the outside of each box. Line the walls and "ceiling" of each box with a different kind of insulation. Put each box over a liter beaker full of boiling water or full of ice cubes and record temperature differences (inside vs. outside and box 1 vs. box 2, etc.) over time.

   You may want to use the "thermos bottle" analogy in introducing this activity. A good thermos has a high surface-to-volume ratio, excellent insulation, a radiant barrier, and only one or two well-sealed openings. It works equally well to keep cool things cool and warm things warm. Slowing heat flow works both ways in a well-designed and insulated building.

3. Build an igloo on the school grounds in winter. Tamp snow firmly into shoe boxes or similar containers. If it is not "packing snow," add some water and let the blocks freeze solid. Pile up "blocks" on a circular base, leaving an opening on the south side. Make each successive layer overhang the previous one slightly on the inside. Use extra snow "mortar" if desired to smooth interior walls. When completed, temperature measurements of inside (warmed by student workers) can be compared to those outside. Ask students to explain differences and to suggest improvements that would make the structure a better heat-conserver. Research on housing styles (past and present) within the Arctic Circle would be appropriate.

4. Contact a local banker, savings-and-loan officer, or home builder familiar with F.H.A. requirements. Ask what current construction practices have been recently adopted with energy conservation in mind. Collect pictures and floor plans of contemporary homes or other buildings where people work, shop, or recreate. Label features that meet or exceed basic requirements for energy efficiency.

5. With cooperation of the school custodian, maintenance supervisor, or other knowledgeable person, survey the school facilities with energy efficiency in mind. Is the school insulated? how? Could insulation, storm windows, shutters, drapes, lowered ceilings, or other energy-saving features be added? Or could activities of the people in the building be changed to save energy? Keep in mind that each person in the school gives off about as much heat as a 100 watt incandescent bulb burning continuously. Can that "people-power" be used?

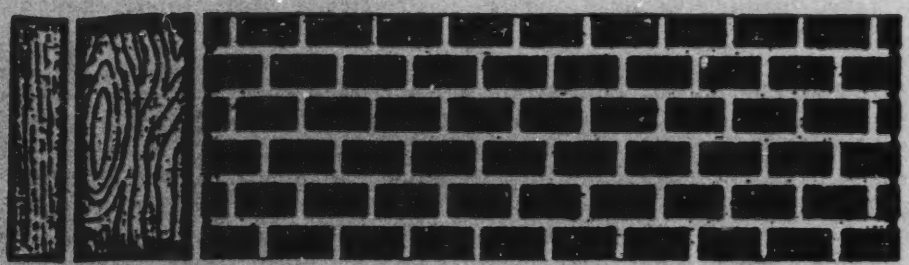
6. Cars, trailers, and motor homes are also "weatherskins" that shelter people from the climate. Cars, at least, are likely to be available on the schoolgrounds and could be subjects for heat-flow measurements. In the Sun, in the shade; windows open, windows closed; different colors, varying amounts of glass area, trunk vs. hood vs. passenger compartment temperature changes over time are all possible forms of data to collect on the efficiency of vehicles to resist heat flow.

Be prepared to discuss conflicting requirements for cars. They should be strong enough to resist demolition; light enough to be economical in use of fuel; comfortable enough to make traveling pleasant; good-looking enough to make people want to buy them. Are there materials that can satisfy those criteria and also minimize heating and cooling requirements for passengers? What would they cost? Would changing people's habits, needs, or expectations be easier than making energy-efficient cars?

Have some students check the additional cost of factory-installed air conditioning on several models of cars, as well as weights of the units. Remind them that these additional 300-500 pounds will reduce fuel economy every time the car is driven--winter or summer--because the greater the weight moved, the greater the amount of fuel needed to move it. Further, when an auto air conditioner is in operation, its use reduces fuel economy by 1-2 mpg, most automotive guides report. How many days a year is this option necessary? How much does it cost to have it available for those days? What other alternatives do motorists have?

Free Resource Suggestion:

Home Energy Savers' Manual, James W. Morrison, ed., 1979, available from Iowa Energy Policy Council, 707 E. Locust, Des Moines, IA 50319. Single copies are available free to teachers. Classroom copies may be available at cost; write for a quotation.

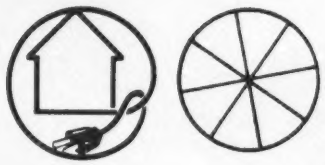


Forget inches: It's R-values that count.
6 inches of fiberglas have the same R-value as 15 inches of wood or 7 feet of brick

The insulating value of any material depends on both the R-value and the amount (thickness) used. The two variables must be juggled simultaneously.

Some insulation guidelines mention inches only, as if quantity and quality are the same. Others specify R-value per inch only. But these are both important and inter-related variables. Total R-value is the sum of R-rating/inch times thickness of the material(s) used over a particular area.

In unfinished floor attics with only 2"-3" space available for insulation, the highest R-value may determine choice, giving maximum resistance possible in a fixed area. But where space is not a limiting factor, cost or availability or ease of installation may make a lower R-inch material, used in quantity, the best choice. Where underground buildings are possible, low R-value masonry and earth berms several feet thick may be the most practical choice for an energy efficient building.



Convenience and Energy

Objective:

To develop the awareness that many resources are depleted in quantity and quality in the name of convenience; that choices between essential needs and non-essential desires are often in conflict; that individuals can extend resource life by careful management.

Procedure:

Ask each student to check at home or the local supermarket for processed convenience foods that are family favorites. The student should list three or four items, weight of the packages, number of servings each provides, and current prices for the quantity specified.

The next day, tabulate these lists during classtime to determine the most often-used items. Determine which of them could be prepared at home using the basic ingredients. From these, select two or three which can actually be prepared in class for comparisons in cash outlays for equivalent servings as well as comparisons on overall quality and nutritional differences (if any) of the convenient vs. "scratch" prepared items.

Some questions you may want to consider discussing are suggested below. Select one or more that correlate with the specific instructional emphasis in your class.

Questions:

1. Were costs of preparing the food at home higher or lower (per serving) than if these items were purchased ready-to-eat from the store?

2. Did you consider the energy cost of using your range and/or water? If not, approximately how much would this add to the cost? Helpful data is available from your local utility companies.

3. Should the time spent (preparing these foods at home [human energy]) be considered in your comparison? Explain.

4. What kinds of energy and materials are used in processing and packaging the convenience foods you have been discussing?

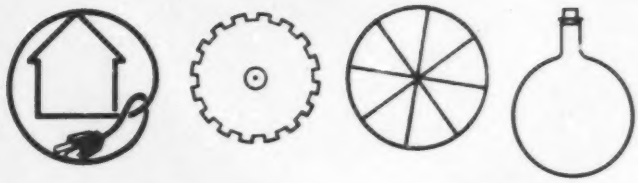
5. Do any of these represent resources which must be conserved?

6. Can any of these materials be re-used?

7. Make a final list of the food items you have decided could be prepared more economically at home.

8. Make another list of food items that require no special preparations at all. Add an asterisk in front of those that can be raised on Iowa farms or gardens.

9. Identify all the energy inputs required to get your favorite processed food to you vs. the energy input required for putting an item from #8 into your diet.



Home and Schools' Energy Efficiency

A project to monitor energy use of your school building and compare it to an average one for your area is a very practical and effective teaching device. Not only that, it can involve the community outside the classroom (schoolboard, taxpayers, parents) which is keenly interested in energy economy as well as the entire staff of the school itself.

Such a project involves students in learning some heat transfer theory, making practical measurements, and doing calculations with guidance from the teacher. They can then apply these techniques to an energy assessment of their own homes.

All the facts you need and step-by-step instructions have been published by Dr. Dale Mordue of Mankato State in his booklet, "Energy Conservation: A Classroom or Do-It-Yourself Project." The booklet is available from Dr. Doris Simonis, Science Education, University of Iowa, Iowa City, IA 52242 for $1.25. Or you can mail your request and $1.50 for a postpaid copy from Dr. Dale Mordue, MSU Physics Department, Mankato, MN 56001.

Several Iowa teachers have had experience with Dr. Mordue's program and they may be helpful resource persons for this recommended activity. Their names and locations follow:

W. D. Ackerman, Hoover High School, Des Moines, IA 50310

D. Lester Carter, Pella High School, Pella, IA 50219

Stephen Dikkers, Guttenberg Jr.-Sr. High School, Guttenberg, IA 52052

Donald E. Liefeld, Central Lyon Sr. High School, Rock Rapids, IA 51246

Larry Nelson, Lakota High School, Lakota, IA 50451

Robert G. O'Connell, Wahlert High School, Dubuque, IA 52001

Roger L. Park, Wayne Community High School, Corydon, IA 50060

Glen Peterson, Le Mars High School, Le Mars, IA 51031

Dwight Williamson, Clear Lake High School, Clear Lake, IA 50428

On the Road to Energy Savings

Introduction:

It is estimated that, if just one gallon of gasoline were saved each week for every automobile in the country, we'd save about 5.6 billion gallons of gasoline in a year. That's about eight percent of the demand created by all our passenger cars. It's easy to see that the effort of each individual can make a difference.

By doing this project, you can find out how much of a difference you can make. You'll learn how much energy your family is using for transportation at present and also how much you can save when you try to conserve energy.

Time Required:

This activity will take you two weeks to complete.

Brief Description of the Project:

During this project you'll be keeping track of the odometer readings (the odometer counts the miles traveled) of one or more of your family's cars, as well as the gallons of gasoline used. You'll first establish a "baseline" week to see how many miles are traveled and how much gasoline is used in a normal week when no attempt is made to cut down. You'll follow that by a "conservation" week where you'll make an all-out effort to reduce the number of miles traveled and increase miles per gallon. Of course, during the conservation week, you'll need to involve all the drivers in your family in the effort to save.

Here's What You Should Do--A Step-By-Step Procedure

Getting Family Cooperation:

If your family has more than one car, you'll want to involve as many cars as possible in this project. For each car involved in the project, someone should be assigned to make odometer readings and record gallons of gasoline purchased. This should logically be the person who buys the gasoline.

The entire family can be involved in going over the booklet entitled "Tips for Energy Savers" from DOE. As a group, you can decide what each family member can do to contribute to the overall savings. A large percentage of a family's budget goes for transportation. Therefore, you'll want to emphasize the economic benefits of conserving in order to convince other family members to participate in the project.

The Trip Log:

Keep a trip log in each car involved in the project. Each time someone takes the car out on the road, they should record the date, the purpose of the trip and the miles driven. At the end of the baseline week, the data collected on this form will be very useful in planning for the conservation week. You and your family should study the data and develop a plan to reduce the number of trips and miles driven during the conservation week. Get each driver to agree to the plan.

The First Odometer Reading:

Find out from your teacher what day you should begin the project. To begin this project, your car's gas tank must be full; otherwise, proper calculations regarding gasoline mileage cannot be made. Therefore, start the project at the gas station. After the tank is full (there is no need to record the number of gallons this time) make a note of your odometer reading (odometer reading #1) on the Recording Form. (You'll need one of these forms for each car involved in the project.) Also, note the date and time of day of this first reading. You'll want to make odometer reading #2 on the same day of the week and at the same time of day exactly one week later.

The Baseline Week:

The week following this first odometer reading is your "baseline" week. The baseline week is used to establish how many miles are traveled and how much gasoline is used in a normal week. During this week, you should make no attempt to institute any new conservation procedures. You can continue to practice those which are already in effect.

All that you will need to do during this week is to record the number of gallons purchased each time you buy additional gasoline. There is room on the recording form for three additional purchases during this week.

The Second Odometer Reading:

Exactly one week after the first odometer reading and at the same time of day (timing is important for meaningful interpretation of results) you should again fill the car's gas tank and record the odometer reading (odometer reading #2). This time you should also make a note of the number of gallons of gasoline purchased. Use the recording forms.

The Conservation Week:

After your second odometer reading is completed you and your family are now ready to begin the "conservation" week. During this week you should do everything possible to reduce the number of miles each automobile is driven and also to increase miles per gallon. Use this "Tips for Energy Savers" booklet as a guideline, but don't be limited by it. If you can think of other ideas, try them out.

If you need additional gas during this week, make sure you note on the recording forms the number of gallons purchased each time.

The Third Odometer Reading:

Exactly one week after the second reading (this should be on the same day of the week and at the same time of day as the two previous readings) take the final odometer reading and note it on the recording form. You should also fill your tank at this time and make a note of the number of gallons of gasoline required.

Using the Odometer to Determine Miles Traveled:

The odometer of your car gives a total, cumulative reading of mileage. To find out how many miles you traveled during a given period of time (for instance, one week), you must compare readings made at the beginning and end of that period.

Study the example below:

First Saturday odometer reads	15,550
Second Saturday odometer reads	15,800
How many miles were traveled?	15,800
	- 15,550
	250 miles

Note: The rightmost dial of your odometer indicates tenths of a mile and can be disregarded for this project.

Computing Miles Per Gallon:

Miles per gallon is the number of miles you get from one gallon of gasoline. Basically, it's an indication of the fuel efficiency of your car.

To compute miles per gallon, you must keep a record of the amount of gasoline added to your tank and the odometer reading at each fill-up. MPG is obtained by dividing the miles traveled since the previous fill-up by the gallons added at the last fill-up. (In other words, you divide the number of miles driven between fill-ups by the number of gallons of gasoline used.) Keeping track of miles per gallon is one way to detect the need for a tune-up when your mileage drops.

Study the example below:

Miles traveled	250
Gallons of gas used	10

Miles per gallon = 250 ÷ 10 = 25 mpg

Recording the Results:

Using the Computation Forms, compute your total miles traveled for the baseline week and the conservation week, and also compute your miles per gallon for each week. Then, find the difference between the two weeks--hopefully a savings in miles traveled and an increase in miles per gallon. If your usage and mileage stayed the same or did not improve, try to figure out why. The discussion suggestions may help you.

Reporting Back to the Class:

Be prepared to report the results of this project to the class. Compare your experiences with those of others. Again, the discussion questions will help you analyze your results.

Where to Go From Here:

Hopefully, you and your family have learned something valuable as a result of this project. You may want to consider implementing many of the conservation procedures on a permanent basis. Plan to save energy and money.

Recording Form

(Use a separate form for each car involved in the project.)

Odometer reading #1 _____	This reading is done at the beginning of the Baseline Week after filling the gas tank. There is no need to record gallons of gas for this filling as it is not needed for the computations.
A___gallons___cost per gallon B___gallons___cost per gallon C___gallons___cost per gallon	If you purchase additional gas during the Baseline Week, record the number of gallons here, and the cost.
Odometer reading #2 _____ D___gallons___cost per gallon	This reading is done at the end of the Baseline Week-start of the Conservation Week after filling the gas tank. Gallons of gasoline and the cost should also be noted for this filling.
E___gallons___cost per gallon F___gallons___cost per gallon G___gallons___cost per gallon	If you purchase additional gas during the Conservation Week, record the number of gallons here, and the cost.
Odometer reading #3 _____ H___gallons___cost per gallon	This reading is done at the end of the Conservation Week after filling the gas tank. Gallons of gasoline and the cost should also be noted for this filling.

Computation Form

(Use a separate form for each car involved in the project)

STEP 1: THE BASELINE WEEK

COMPUTING MILES TRAVELED

Odometer reading #2	-	Odometer reading #1	=	Miles traveled

COMPUTING MILES PER GALLON

Miles traveled	÷	Total gallons of gas used (add together all fill-ups under A, B, C and D)	=	Miles per gallon

STEP 2: THE CONSERVATION WEEK

COMPUTING MILES TRAVELED

Odometer reading #3	-	Odometer reading #2	=	Miles traveled

COMPUTING MILES PER GALLON

Miles traveled	÷	Total gallons of gas used (add together all fill-ups under E, F, G and H)	=	Miles per gallon mpg

STEP 3: SAVINGS

COMPUTING SAVINGS IN MILES TRAVELED

Miles traveled first week	-	Miles traveled second week	=	Savings in miles traveled

COMPUTING INCREASE IN MILES PER GALLON (MPG)

mpg 2nd week	-	mpg 1st week	=	Increase in mpg

Trip Log

Keep this trip log in the car and make a record each time you take the car out on the road. You will need one of these forms for each car involved in the project.

Baseline Week			Conservation Week		
Date	Purpose	Odometer Reading	Date	Purpose	Odometer Reading

Discussion Questions:

Congratulations if your computations indicate a savings in miles traveled and/or an increase in miles per gallon. If things stayed pretty much the same during the two weeks, or if they got worse during the second week of the project, can you think of any reasons why this occurred? Some things you might consider are as follows:

Family was already energy-conscious--no room for improvement.
Family took a long trip during the second week.
It was your parents' turn to drive for the carpool during the second week.

Keep in mind that, if you had a savings, it could have been that things of this type were operating in your favor.

Use a separate sheet of paper to answer the following questions:

1. Regardless of your results, write a short paragraph describing any unusual circumstances which may have affected the outcome.

2. If you were successful in reducing miles traveled and/or increasing miles per gallon, specify which conservation effort you feel is responsible for this result.

3. Were there any major changes in your family's life style during the conservation week? (For instance, your parents joined a carpool; or you walked, rather than drove, to school, etc.) Please describe.

4. Based on current gasoline prices, compute the cost of the gasoline used during the baseline week and the conservation week. These amounts can be multiplied by 52 to find out yearly costs with and without conservation.

5. Check the owner's manual in your car to determine vehicle weight, number of cylinders and size of engine (cubic inches). Also, make a note of any optional equipment the car has. How do you think these factors affected your conservation attempts?

6. Does your family plan to continue any of the conservation practices initiated during the second week of the project? If so, which ones?

7. Which conservation practices will not be continued, and why not?

Teacher's Guide to On the Road to Energy Savings*

During this activity, students will keep records of odometer readings and gasoline consumption for as many of their family's cars as possible. They will be asked to establish a "baseline" week to determine how many miles are traveled and how much gasoline is used in a normal week when no attempt is made to cut down. This will be followed by a "conservation" week where attempts are made to reduce miles traveled and increase miles per gallon. The entire family is asked to participate in the effort.

After completing this project, students should:

1. Know what an odometer is and be able to compute miles traveled.
2. Know how to compute miles per gallon.
3. Know how many miles their family travels and the gasoline mileage their car gets in a "baseline" week as compared to a week where they make an intensive effort to conserve, as well as the cost factors involved.
4. Be familiar with various energy conservation procedures for transportation.
5. Have a positive attitude toward conserving energy.

Suggested Procedure:

Two months ahead of classtime, order bulk copies of the free booklet, "Tips for Energy Savers" from U.S. DOE, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

The project can be introduced with a lesson on odometers and how to compute miles traveled and miles per gallon. The curriculum package provides complete instructions for this purpose.

The project can be explained by going over the "Student Instructions" with the class. Time should also be spent going over the "Tips for Energy Savers."

During the first class meeting after the students do the initial odometer reading, time should be allotted to answer questions and straighten out problems students might be having with this part of the project.

As students approach the conservation week, a class discussion of their plans for that week and strategies for involving other family members would be very helpful. The trip logs for the first week could also be discussed.

**This activity was originally prepared by Nancy J. Leedom for the Youth Energy Project of the Michigan Department of Commerce.*

Finally, when the project is completed, several class periods can be devoted to interpretation and discussion of results, using the "Discussion Questions" in the curriculum package as a guideline. Students should be encouraged to share with each other their results and their experiences during the project. A summary of individual results on a bulletin board would be a good reinforcer for energy saving behavior.

Related Activities by Type of Class:

These activities are optional. They are suggested as a means to reinforce what is learned by doing the project. They are also designed to suggest how the project might fit into an "energy unit" in your class.

Language Arts, English and Speech

1. Have students write an essay or give a speech persuading others to change their driving habits to conserve fuel by reducing miles traveled and attempting to increase miles per gallon. The best essays could be submitted to the school or local newspaper. Other topics for essays and speeches: "Advantages of the 55 mph speed limit"; "Advantages and disadvantages of small cars."

2. Have students research and give a "how to" speech on car maintenance or tips on buying a new car.

3. Have students develop a series entitled "Energy Tip of the Day" to be broadcast along with daily school announcements.

4. Have students develop an energy conservation newsletter for transportation or have them develop and tape short energy conservation "commercials".

Mathematics/Science

1. Have students graph their miles traveled, gasoline usage and miles per gallon for the two weeks of the project.

2. Students could compute average usage for a family, group results and community results.

3. To demonstrate the importance of car pooling, students could learn how to compute "passenger miles per gallon" (pmpg), according to the following formula:

   pmpg = Number of passengers x miles per gallon

Example: Car with 3 passengers getting 20 mpg gets
3 x 20 = 60 pmpg

Bus with 30 passengers getting 6 mpg gets
30 x 6 = 180 pmpg

Art

1. Have students prepare a bulletin board display for some prominent location in the school. Use the "Tips for Energy Savers" for topic ideas.

American History/Social Sciences/Economics

1. Present students with the following hypothetical situation: "Suppose that the federal government decided on a policy of conserving gasoline by reducing the number of automobiles in this country." Ask them to come up with proposals for implementing such a policy, including who would be affected and how the policy would be enforced. Ask them to list some possible consequences of such action.

2. Have students report on the gas rationing program during World War II. They should answer the following questions: How did it work? What were some of the problems? Could the same system be used today?

3. Have students write an essay on the relationship of income and personal transportation. The essay should also deal with the idea of the car as a "status symbol".

4. Have students investigate mass transportation systems in other cities and come up with a plan of their own to improve their local system.

Home Economics

1. Students could find out what percentage of the family budget goes toward transportation energy. (25% was the national average in 1979.)

2. Ask students to discuss how "giving up" their family cars could affect their life-style.

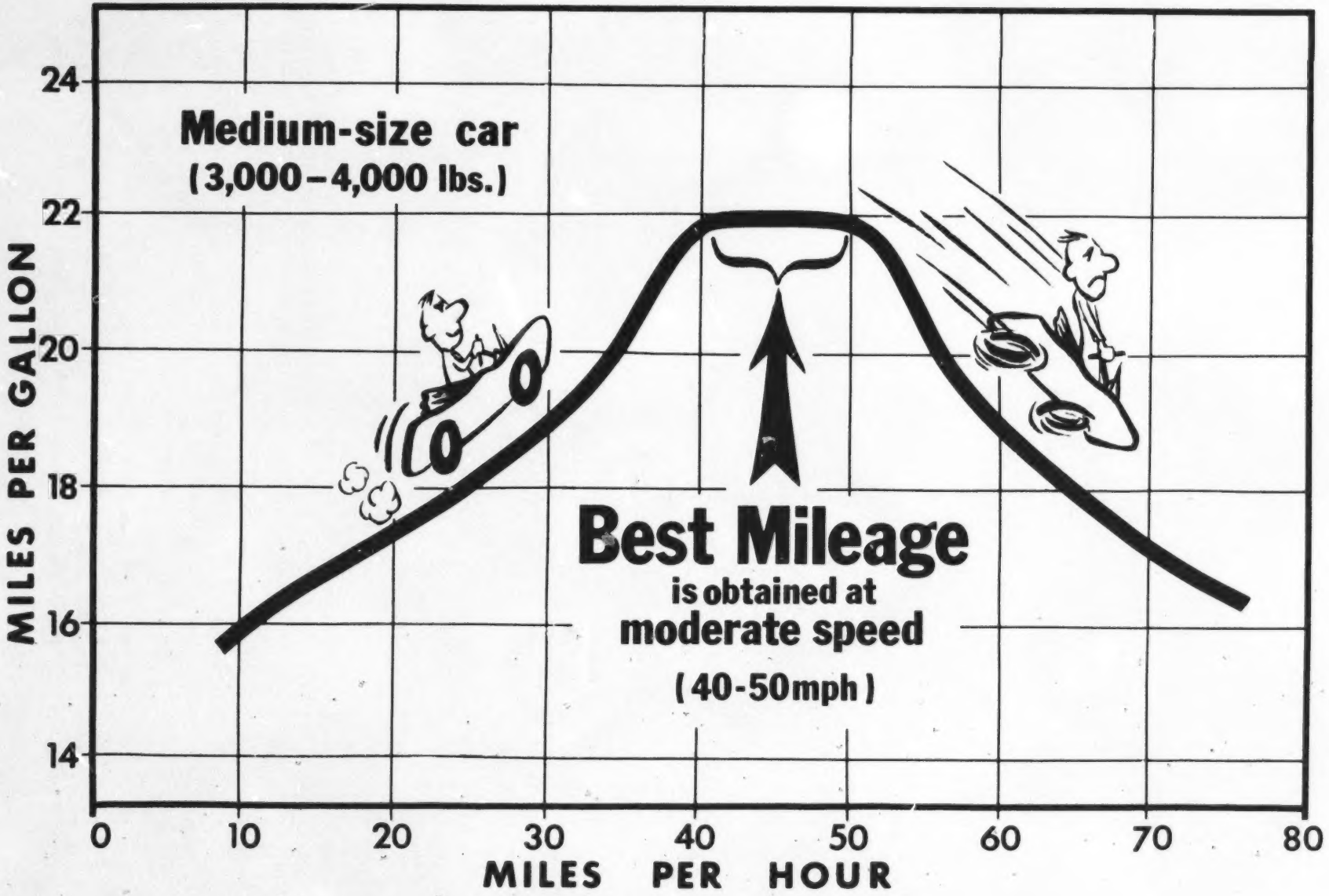
3. Students could devise with a car-pooling campaign for those students and teachers who drive to school. Included in this should be a list of the conditions which must be met for car pools to succeed.

Driver Education

1. Students could be assigned to groups which would research the major topics of the tips booklet related to cars. They could elaborate on these topics and also suggest with additional ideas which they would report back to the class.

2. Obtain a copy of the "EPA/FEA Gas Mileage Guide" by writing to Fuel Economy, Pueblo, CO 81009. Have students compare their miles per gallon during the project to the estimates in this guide.

3. Ask students to research a paper on energy-saving innovations in automobile design. They could investigate electrically powered cars, as well as newly popular engine types like the diesel. The paper should address the question of whether these innovations are the answer to our energy problem.



Data from American Automobile Association.

Transportation: Carpooling Saves

Objective:

To develop awareness of the costs of operating a car and of the cash savings possible by carpooling.

Background:

Some people do it to save money. Some do it to conserve energy. Some enjoy the companionship during an otherwise lonely time of day. Some are in it strictly for the ride. These are the car poolers who share the daily commuting on a voluntary basis. And these are also the van poolers who pay to ride in a company-sponsored vehicle.

At least 150 major corporations around the country operate vans to transport employees to and from work (according to the Wall Street Journal, Jan. 23, 1979). Commuters say they save $1-$3 per day in travel expenses by van pooling. It reduces wear and tear on autos, and lowers the expenses of parking and fuel. Some commuters also get reduced auto insurance rates because they no longer drive to work.

Companies say that van pooling boosts employee morale, reduces absenteeism, and avoids the expense of providing individual parking places for employees. The vans usually pay for themselves, too. Fares are set on a mileage basis that takes into account the original cost of the van, less its resale value, along with fuel, insurance, taxes, and maintenance expenses over the three to four year average use. Drivers who set up their own carpools can make similar estimates in order to charge each rider a fair share.

Procedure:

Using the following figures (or up-to-date ones, as available), have students figure the costs of driving to and from school:

Car Type	Costs per mile					
	Depreciation (cents)	Parts & Tires (cents)	Gas & Oil (cents)	Insurance (cents)	Taxes (cents)	Total Cost (cents)
Standard	12	5	7.5	2.1	1.7	28.3
Mid-Size	11	5	5.5	2.0	1.6	25.1
Compact	9	4	4.5	2.0	1.3	20.3
Sub compact	7	4	4.0	2.0	1.0	18.0

Example:

To figure commuting cost, multiply number of miles (say 20) times cost for a mid-size car (Chevy Malibu)--

1. 20 x $.251 = $5.02

2. Add daily parking fee + $.50

3. Total daily cost $5.52

4. Multiply daily cost x number of school days per month (21) for total cost per month to drive alone ($115.92).

5. Divide this by the number of people in the carpool (say 4)--

   $115.92 ÷ 4 = $28.98, cost per passenger in car pool

6. Monthly savings, per person, is the difference in cost between driving individually and using the carpool.

   $115.92 - $28.98 = $86.94

Note that more than money is saved. Energy use is reduced, and environmental damage is also less. Parking areas do not have to be so large and the atmosphere does not have to absorb so much heat and exhaust fumes.

Now have each student compute his own commuting costs, those of a parent, or those of the "typical worker" at a nearby industry. An answer sheet is provided.

Additional Resources:

Free class copies of current gas mileage guides from U.S. Department of Energy, Fuel Economy Distribution, Office of Administrative Services, Washington, DC 20585.

Federal Highway Department Statistics from U.S. Department of Transportation, 400 Seventh Street, SW, Washington, DC 20590.

STUDENT WORKSHEET Name_____

Carpooling Cost Estimates

1. Multiply cost per mile x miles per day:

_____ x _____ = $ _____

2. Add daily parking cost + _____

Daily cost TOTAL:

3. Multiply daily cost by number of school (working) days per month x_____
Lone driver's monthly cost TOTAL:

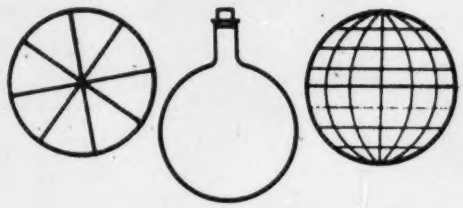
4. Divide monthly cost of driving alone by number of people in carpool ÷_____

5. New cost per person by carpooling =
_____

6. Monthly carpool savings, #3 - #5

$_____ - $_____ = $_____

7. What other differences (besides personal savings) might carpooling make in your life?



Energy Converters and Power

Time is involved in most considerations of energy flows. Power means the energy available per unit of time--for example, so many calories per second or Joules per second or watts are common units of power.* Low-energy flows (from a low-powered mover or machine) can sometimes do the same job as a high-energy flow if time is not a critical factor.

Each of the movers listed below converts energy (food or fuel or a natural force) to power.

Power Output of Selected Energy-Converters

Basic Converter	Typical Power Output (in kilowatts)
Man	0.1
Ox	0.2
Horse	0.5
Windmill	15.
Waterwheel	300.
Steam engine	2,000.
Internal combustion engine	10,000.
Gas turbine	80,000.
Water turbine	100,000.
Steam turbine	1,000,000.
Liquid fuel rocket	16,000,000.

*The watt is a unit of energy per unit of time. One watt is one joule per second or 0.239 calories per second or .0002 Calories per second. Human metabolism converts chemical energy at a rate of approximately 100 watts, or 0.1 kilowatts.

Teacher's Guide to Energy Converters and Power

There are many ways to use the information on ENERGY CONVERTERS AND POWER with your class. Some involve math; some develop a sense of scale useful in art, science, and history; some require getting additional information and/or making value decisions. Choose one or more that suits you and the subject you teach.

Mathematics:

1. Calculate some differences in the power outputs of various converters. For example, how much more energy per second (power) is released by a rocket than by a man?

   (16,000,000 ÷ 0.1 = 160,000,000)

2. How much more powerful is a steam turbine than a steam engine?

   (1,000,000 ÷ 2,000 = 500)

3. Convert all the power ratings to "powers of 10."

Energy-Converter Chart
expressed in powers of 10

Man	1×10^{-1}	kilowatts, power output
Ox	2×10^{-1}	kilowatts, power output
Horse	5×10^{-1}	kilowatts, power output
Windmill	1.5×10^{1}	kilowatts, power output
Waterwheel	3.0×10^{2}	kilowatts, power output
Steam engine	2.0×10^{3}	kilowatts, power output
Int. comb. engine	1.0×10^{4}	kilowatts, power output
Gas turbine	8.0×10^{4}	kilowatts, power output
Water turbine	1.0×10^{5}	kilowatts, power output
Steam turbine	1.0×10^{6}	kilowatts, power output
Rocket	1.6×10^{7}	kilowatts, power output

4. Each "power of ten" is often called "one order of magnitude" in scientific literature. How many orders of magnitude are there from man's power output to the rocket blast?

   (Eight. Don't forget a place for 10^{0} between 10^{-1} and 10^{1}.)

Graphics:

Make a histogram, pictograph, or other scalar method of the comparisons listed on the Energy Converter table. Suggestions follow:

1. Use an adding machine tape to block out proportional areas related to power. One full tape may be used for a cooperative effort OR give each student a piece of adding machine paper about 4 yds. or 4 m long OR make your own long sheets of paper by taping pieces together OR use discarded runs of computer paper.

   A practical ratio to use is 1 mm^2 per unit of human power or 0.1 kw. Then the ox's output can be represented by a rectangle 1 x 2 mm; the horse, by a rectangle 1 or 5 mm; the windmill, 3 x 5 mm; the waterwheel, 8 x 375 mm or 6 x 500 mm or 10 x 300 mm, etc., depending on dimensions of your paper; the steam engine, by a rectangle 8 x 2500 mm or 5 x 4000 mm, and so on. This sort of two-dimensional model dramatically illustrates the power ratios between various converters . . . but you'll only get as far as steam power on a short length (4 m or 4 yds.) of paper. If you've opted for individual efforts, then, when realization dawns that there's not enough room to complete the model, ask how many of the individual strips put together would be needed to represent the internal combustion engine, the gas turbine, the water turbine, etc.

2. If you have use of balance scales and about 3 pounds of clay, make models of the orders and magnitude (powers of 10) on the basis of 1 g clay vs. 10 g clay vs. 100 g clay vs. 1,000 g clay. (You can go to 10,000 g if you have it, but the later stage alone would require 22 lbs. of clay.)

3. Make a step-wise illustration showing power relationships of the converters on a scale representing the orders of magnitude (powers of 10) of their differences. This cannot be a true graph because the power sources are not related entities (see example).

   OR, make a historical power grid, using the same orders of magnitude (suggested above) on the vertical scale, but putting historical time (perhaps also expressed in powers of 10 as "years ago"?) on the horizontal scale. The data provided on the Energy Calendar in this book will be helpful for this approach. You may have to check an encyclopedia for some dates.

4. Using a compass and protractor, make a circular pictograph of the representative fractions of "energy output." Each named component would represent a segment of the total energy outputs mentioned in the original data chart. Based on the sum of 17,192,315.8 kw or 17.2 x 10^6 kw in a 360° circle, each degree would represent 47.8 x 10^3 kw (or, each million kw would be represented by 360° ÷ 17.2 million kw = 20.9°). Thus the major portion of the energy released is represented by the modern rocket (334°), the steam engine is a wedge of 20.9°, and all others are included in the remainder. (See example provided.)

Questions, Thinklers, Discussion Topics:

1. Find out how the historical progression in energy use correlates with the escalation in power outputs. When did waterwheels come into use, for example--before or after windmills? Which turbine is the newest? Attempt to date and put in chronological order all of the basic converters listed on the chart.

2. Consider the INPUT for each basic converter.

   a. What is the origin (fuel or force) of its energy?
   b. Is this INPUT available (renewable) on a human time scale?

3. Does the rate of INPUT match the rate of OUTPUT? (Keep in mind the "one-second" time scale.)

4. What is the useful lifetime of each converter? Do you find any examples of "tortoises" and "hares"?

5. What kind of work would each converter ordinarily do?

6. Which of these converters have contributed to your present standard of living?

7. Which of them can you most easily live without?

8. Which of them are essential to your survival?

9. Can humankind ever have "too much" power?

Role Playing-Simulation:

Assign each student one of the "converters" to research. Ask the student to use the library to find out the history and development of that particular energy converter: fuel requirements for it; nature, quality and importance of the work by this converter (past, present, future?); environmental effects; and social feedbacks from use of this converter.

Based on the information gained in the above assignment, have each student show his knowledge of the particular converter by:

Writing advertising copy or preparing a radio commercial extolling its virtues;

Considering what kind(s) of insurance coverage it would need to protect itself from liability claims; what are its particular hazards?

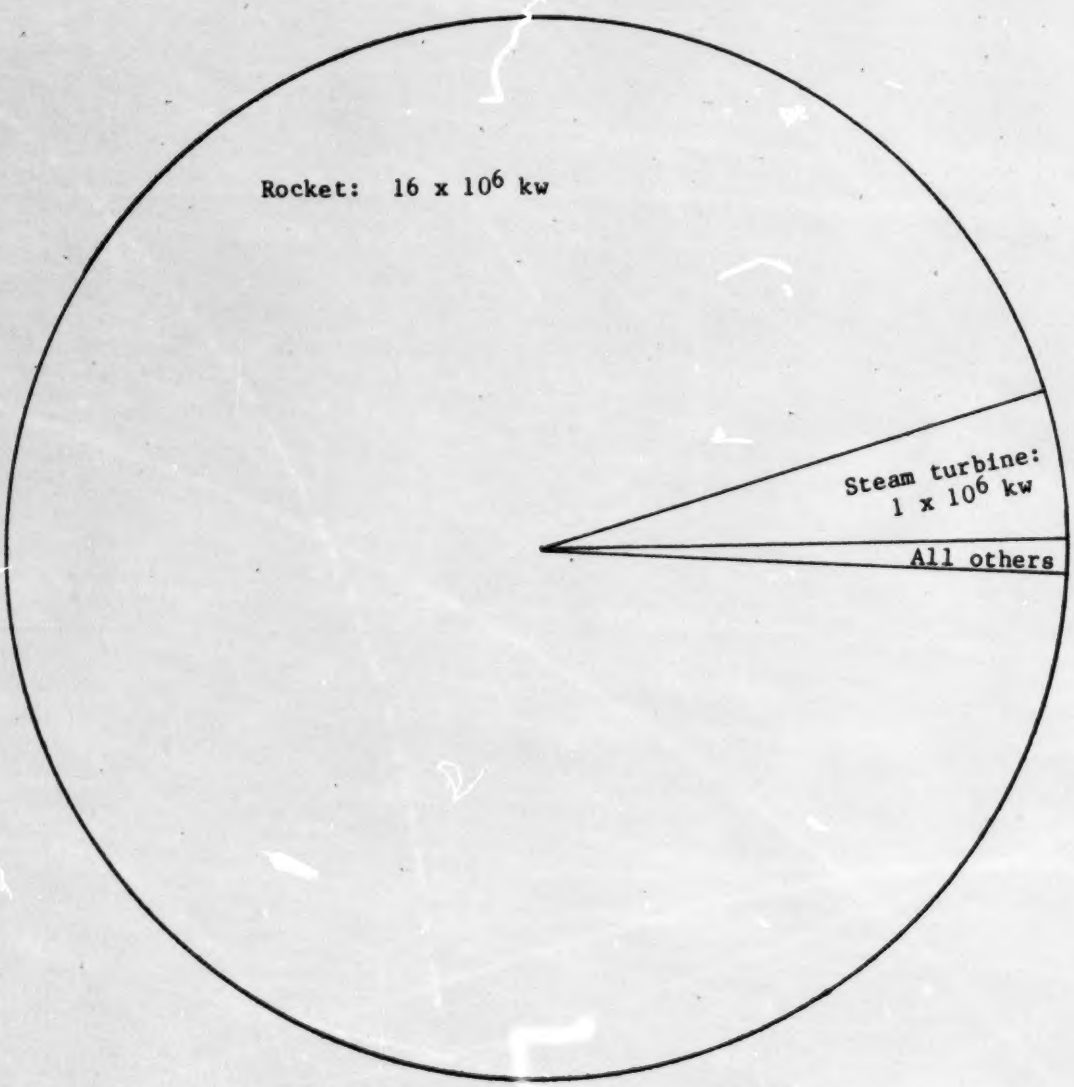
Explaining how it does (or doesn't) relate to other energy converters.

Or assign two students to each converter, one to research its advantages and one to look into its limitations. Have each prepare a three minute report. Then put each converter "on trial" for a few minutes. Have one student present his

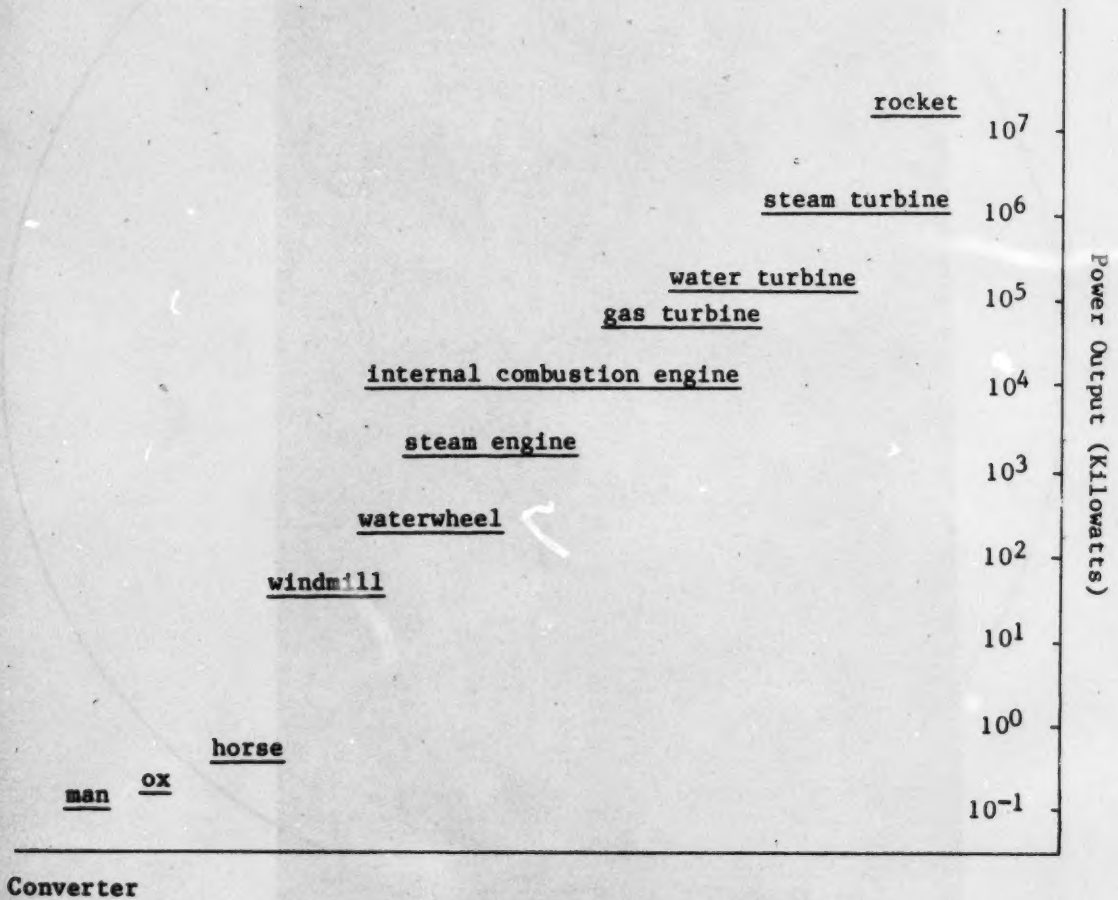
"case" for allowing this converter to escape the "death penalty." Then have the second student present his objections to continued use of this particular machine. Let the class "vote" on the merits of their arguments. If the "cases" are well-prepared, many "hung juries" are likely.

ONE-SECOND TIME MACHINE

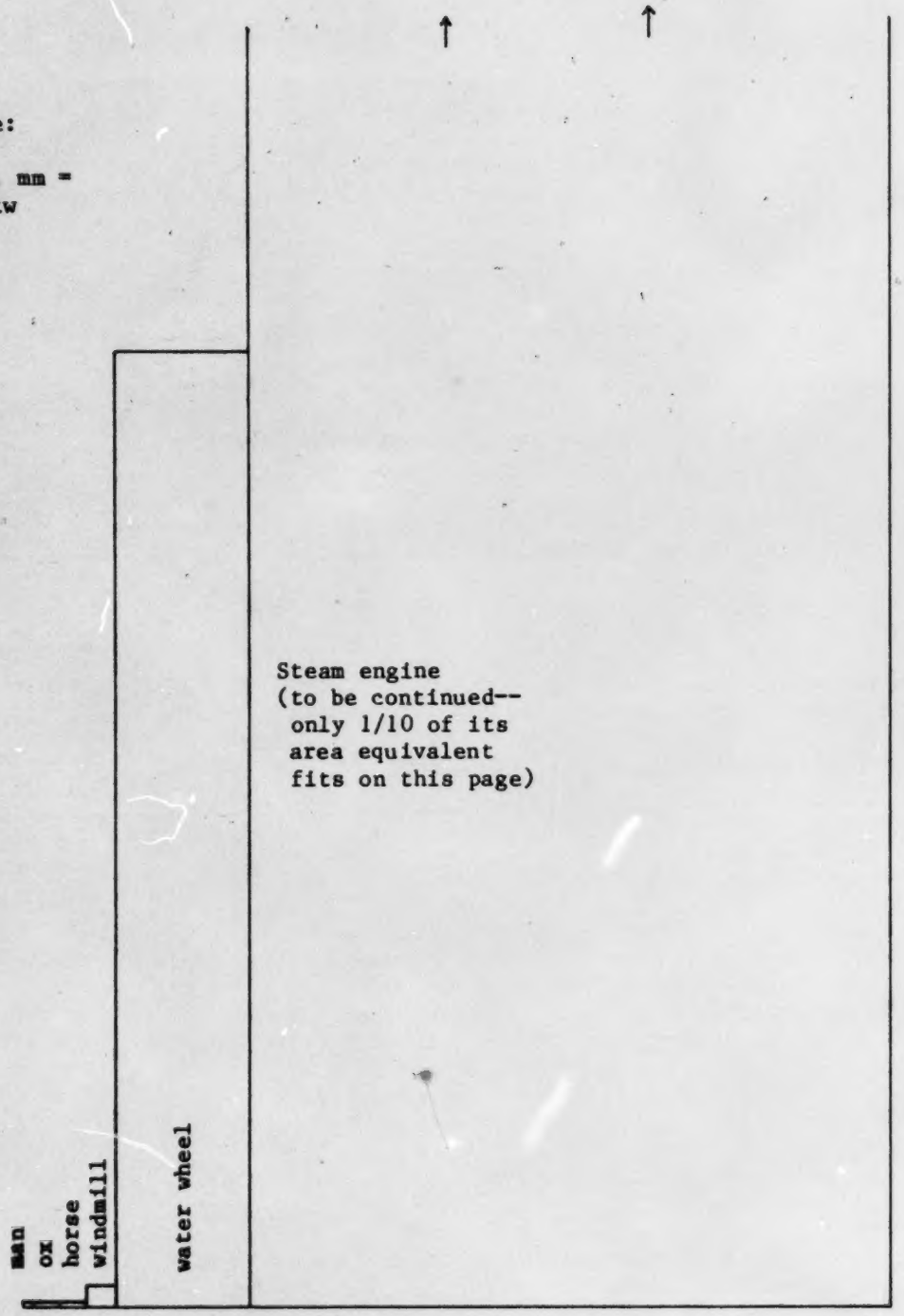
(model of energy output in kilowatts)



Non-exact model for possible graphic presentation of
Table on "Power Output of Selected Energy Converters"



Typical Power Output of Some Energy-Converters



Example of Area-to-Power Graphic

AN ENERGY CALENDAR

Birthday of planet Earth was 4.5 billion years ago.

Oldest known rocks are 3.3 billion years old.
First plants (algae) appeared 3.2 billion years ago.

First known animals (jellyfish) died 1.2 billion years ago.
Fossils first became abundant 600 million years ago.

Age of fishes began 400 million years ago.
Fern-like plants grew densely, became basis of COAL, 300 million years ago.

First dinosaurs thrived 225 million years ago.
First mammals appeared 200 million years ago.

Decline of dinosaurs occurred about 135 million years ago. Along with fossil plants, some became fossil soup (PETROLEUM).
First primates trapped in a fossil record lived 70 million years ago.

Man-like creatures appeared about 3 million years ago.
Ice Ages began 1.7 million (1,700,000) years ago.

Man began to use fire, 500,000 B.C.
Last glaciers retreated, 8000 B.C.

Man learned to smelt metal and make bronze, 3000 B.C.
Iron technology was begun, 1000 B.C.

Waterwheels were used in Greece, 300 B.C.
Book by Vitruvius describes watermills, steam jets, and other machines, 27 B.C.

Mt. Vesuvius destroys Pompeii, 79 A.D.
Waterwheels come to Europe, 500 A.D.

First windmills were used 650 A.D.
Coal was burned in an English monastery, 852 A.D.

Whale oil came into use for lighting, 900 A.D.
Coal was regularly used for home heating in Newcastle, England, 1300 A.D.

Windmills started to drain the Netherlands, 1500 A.D.
Modern steam engine was conceived by Watt, 1765.

First oil well was drilled in Pennsylvania, 1857.
Otto designed the 4-stroke internal combustion engine, 1876.

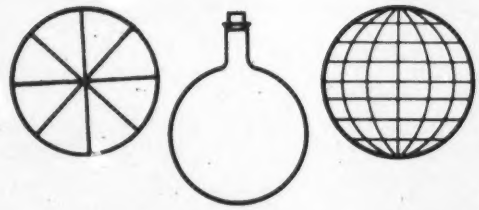
First incandescent lighting was provided to a small area of New York City, 1882.
Becquerel discovered radioactivity, 1896.

Wright brothers flew the first successful airplane, 1903.
First jet plane flew, 1942.

First nuclear explosions were detonated in 1945.
First nuclear electric power plant in the U.S. was completed, 1958.

Man first walked on the moon in 1969.
"Energy Crisis" of limited supplies and higher fuel prices became a public concern in the winter of 1973-74.

Now—?



An Historical Digest:
Energy Storage and Use

Every living thing is an energy converter and an energy storage tank as well. Usually small plants like bacteria and fungi decompose dead plants and animals. The results are water, carbon dioxide, and mineral residues that can be rather quickly reused by another season's growth.

In our midwestern climate, dead leaves spread over garden soil usually decompose completely in less than a year's time. The body of a bird buried in a paper box "disappears" in six months or less, depending on the season. Decomposers work faster in summer and in milder climates. However, sometimes plant and animal remains are buried by mud, mineral-rich water, ice, rockslides, volcanic activities, or other natural agents. The result may be to limit the amount of oxygen or other necessary resources for the process of decay.

Any covering also has weight, putting pressure on the organic materials. then the products of incomplete decomposition, trapped in a pocket or layer of earth's crust, may become compressed packages of concentrated energy called gas, petroleum, and coal.

The repackaging of plant energy into such concentrated form took hundreds of millions of years. Geologists think that most of the world's coal is the remains of land plants that thrived 300-500 million years ago. They assume that Earth was warmer and wetter and that the atmosphere had more carbon dioxide than it does now, conditions favoring luxuriant plant growth.

Oil is believed to be the remains of marine animals and plants that sunk to the bottom of great inland seas that covered Earth tens of millions of years ago. The pressure of accumulating sediments on the decaying plants and animals and the resulting heat of compression helped to cook an energy-rich soup. The broth was rich in many complex hydrocarbons (petroleum) plus the lighter simple hydrocarbon we call natural gas.

These energy resources or fossil fuels were produced and stored under Earth's surface long before any men appeared. The first peoples of Earth knew nothing of these buried treasures. They kept alive and warm by the food they gathered and hunted, and the coverings they made for their bodies. They learned to shelter themselves from seasonal winds by using caves. Eventually some persons among them learned to use and control fire which was started by lightning.

Fire provided extra warmth, protection from predators, and light that extended time for people. No longer did darkness bring only sleep. They gained extra hours for socializing, developing language, making pictures, fashioning better tools, keeping records. For the first time they could plan excursions into areas of the world that had greater seasonal changes, letting fire be their portable heater.

Ice Ages came and went, perhaps as many as twenty of them. The most recent one ebbed approximately 10,000 years ago. Man survived, with wood still his primary fire source. He became more efficient in collecting solar energy, however, as he became adept in growing and harvesting crops and in domesticating animals both for power and for meat.

Some people learned to use vegetable oil (olive oil in particular) for lamps, and others used candles of rendered animal fat (tallow). Whale oil was used more than 1,000 years ago. Beeswax was long popular for its clean burning compared to tallow. All of these, as well as wood, were renewable energy sources, those that could be regrown over periods of time that are short compared to the length of a man's life.

Then someone discovered coal. By the 13th century A.D. persons living near Newcastle, England were using it regularly. It was probably easier to dig up a few bucketsful there than to find and cut an equivalent amount of firewood to keep the home fires burning. Also, the supply of coal seemed endless.

Although some people were using coal as early as the 9th century, for the first thousand years of consumption the rate of use was very low. There were fewer people than now. Houses were smaller. Nearly all work was done in, or around, the home. There were no offices, large stores, and factories to heat. Churches and theaters had no heat nor water. People traveled on foot, on horseback, or in animal-powered carts. Their clothes were hand-crafted products of natural materials: linen, cotton, wool, silk, and fur.

The situation changed in the 19th century. Rapid industrialization, mechanical transportation systems, changing lifestyles, and rapid population growth all contributed to a persistent increase in the amount of energy consumed.

Petroleum became a significant part of the energy picture more than 100 years ago. The booming oil industry nearly doubled its production every eight years from 1870 to 1970. Much of this inherited mineral wealth was spent for production of energy-consuming technologies. Man has brought himself many comforts and services by harnessing machines and has enlarged his list of "necessities for the good life" in the process.

AN HISTORICAL DIGEST

Activity:

Modeling the time scale of energy storage and use.

Materials needed:

Energy Calendar
Wall or floor space
Meter sticks or rulers with metric scale
Masking tape
Pens or pencils
2 rolls of standard adding machine paper (per class)
or
2 spools of thread (500 yds.) plus toothpicks and paper

Procedure:

Tape a roll of adding machine paper around the classroom walls, or spread it on the floor, or use a corridor (whichever your teacher suggests). Assume that it is about 45 meters long. You are going to let this length of paper represent the whole 4 1/2 billion year history of Earth as outlined on your Energy Calendar. What will the scale of your model be?

If you use the entire tape and it is 45 m long, 45 : 4,500,000,000 as 1 : 100,000,000 or 1 m represents 100,000,000 years. This is the "upper limit" (unless you have additional tape and space to spread it out).

If you use the ratio of 1 m = 100 million years, how much time does 1 mm represent?

What other ratios could you use?

Mark the beginning of the paper tape as the beginning of Earth time or as Now, depending on which direction your group prefers to work (from past to present, or from present to past). Then enter the next event in the sequence at the appropriate distance from "start" of your tape. Continue to enter all the Energy Calendar dates, one at a time, at carefully measured intervals so that a fair relationship is kept.

If your group has difficulty getting the most recent events represented on your paper roll, you may want to "expand" only the more current events involving man's use of energy on another roll or sheet of paper. Choose another ratio of length to time that allows space for the entries you'd like to make.

Note here--the time span I'd like to account for is _____ years.

Then if 1 mm represents 1 yr., I'd need a paper _____ long.

Or, if 1 mm represents 10 yrs., I'd need a paper _____ long.

Using the paper provided by your teacher, measure off the intervals on your "expanded" scale and identify each mark according to the event it represents.

If you are using thread instead of paper, secure one end with a thumbtack to a desk edge. Or have a fellow student hold it. Tie a toothpick into the thread at proper intervals for the events they represent. You can attach paper labels to the toothpicks to identify the calendar listings. Calculate the scale on the basis of having 450 m of thread.

Extended Activity:

You now have a graphic model of some energy-related events on Earth. But this is only one way to show how short a time man has intensively used concentrated fuels that were stored for millions of years. Here you have expressed one kind of measure, time, in terms of another, linear space. Can you think of a more timely model?

Compare the age of Earth to a single day. Then how long would the duration of man's use of fossil fuels be?

Or, what if the age of Earth were compared to your age? Then how long would man's energy binge (the last 110 years) be in that analogy?

AN ENERGY CALENDAR

Birthday of planet Earth was 4.5 billion years ago.

Oldest known rocks are 3.3 billion years old.
First plants (algae) appeared 3.2 billion years ago.

First known animals (jellyfish) died 1.2 billion years ago.
Fossils first became abundant 600 million years ago.

Age of fishes began 400 million years ago.
Fern-like plants grew densely, became basis of COAL, 300 million years ago.

First dinosaurs thrived 225 million years ago.
First mammals appeared 200 million years ago.

Decline of dinosaurs occurred about 135 million years ago. Along with fossil plants, some became fossil soup (PETROLEUM).
First primates trapped in a fossil record lived 70 million years ago.

Man-like creatures appeared about 3 million years ago.
Ice Ages began 1.7 million (1,700,000) years ago.

Man began to use fire, 500,000 B.C.
Last glaciers retreated, 8000 B.C.

Man learned to smelt metal and make bronze, 3000 B.C.
Iron technology was begun, 1000 B.C.

Waterwheels were used in Greece, 300 B.C.
Book by Vitruvius describes watermills, steam jets, and other machines, 27 B.C.

Mt. Vesuvius destroys Pompeii, 79 A.D.
Waterwheels come to Europe, 500 A.D.

First windmills were used 650 A.D.
Coal was burned in an English monastery, 852 A.D.

Whale oil came into use for lighting, 900 A.D.
Coal was regularly used for home heating in Newcastle, England, 1300 A.D.

Windmills started to drain the Netherlands, 1500 A.D.
Modern steam engine was conceived by Watt, 1765.

First oil well was drilled in Pennsylvania, 1857.
Otto designed the 4-stroke internal combustion engine, 1876.

First incandescent lighting was provided to a small area of New York City, 1882.
Becquerel discovered radioactivity, 1896.

Wright brothers flew the first successful airplane, 1903.
First jet plane flew, 1942.

First nuclear explosions were detonated in 1945.
First nuclear electric power plant in the U.S. was completed, 1958.

Man first walked on the moon in 1969.
"Energy Crisis" of limited supplies and higher fuel prices became a public concern in the winter of 1973-74.

Now--?

Teacher's Guide to An Historical Digest

This activity requires one or two class periods, depending on how much preparatory discussion (if any) your class needs, and whether or not you follow up the model-making with discussion of models in general--reasons for keeping equal proportions, areas of similarity and differences, alternative media possibilities, etc. The optional extended activities would also probably require a second or third class period.

Materials to be procured in advance are 2-5 adding machine rolls (number depending on class size and whether or not the "expanded section" is done as a group or individually) OR two 500-750 yard rolls of thread and a box of flat toothpicks. Duplicate the "Energy Calendar" as well as the instruction sheets so that every student has a copy. Provide meter sticks or rulers with the metric scale.

Procedure assumes a cooperative class venture.

Note that there are a total of 36 events on the calendar. It is suggested that each student be assigned to measure off the place for at least one of them.

If the class is large, you may want to divide it into two working groups. Let one work on the "maxi-scale" of the first 14 or 15 dates. There will be great difficulty (impossibility!) in fitting in any recent dates (since man's first use of fire). So you may assign the second group to work on a separate tape representing the energy chronology starting with man's use of fire. The scale chosen should, of course, be different.

What should the ratio of length to time be? You may wish to let the class decide. Students are advised on the instruction sheet that the tape is about 45 m long, so with Earth's existence represented by the entire length of tape, the maximum scale available is 1 m to 100,000,000 years. Then 1 cm represents 1,000,000 years and 1 mm is 100,000 years.

To plot the smaller time segment of 500,000 years, the expanded scale can be 1 m = 10,000 years if a whole roll is used, or 1 m = 50,000 years if only 10 m are used.

You will need the perimeter of a large room for spreading out the roll. A corridor floor or a gym wall is ideal. Or you can double-back lengths of tape along a classroom wall or blackboard. Use masking tape to hold the paper to the wall or floor where students can measure out the appropriate lengths and also see the whole sweep at once.

Assign each student responsibility for marking location of at least one of the dates on the Energy Calendar onto the class's timeline. Have the class decide whether to start with Now or with "birthday of Earth" on one end of the tape and then mark in the other events at appropriate intervals.

Whether or not the "expanded model" of the shorter time period from now to 500,000 B.C. is subject for another whole roll of tape or for only about 10 m of one depends on the space available to you. Anything less than 10 m is impractical for group work (too much crowding and shoving at close quarters). Instead you may prefer to give short lengths, like 5 m (representing 500,000 years so 1 mm = 100 years) to each student for individual scaling and completion of a man/energy time-line.

Thread gives an interesting alternative because it allows greater length in less space. Again, assign each student an event on the Energy Calendar. Let one be anchor man, representing "birthday of Earth," holding one end of the thread. Or, if you have a convenient place to thumbtack one end, you may prefer to do that. Then have students measure out lengths in proportion to the time intervals--about 10 million years to each meter; 10,000 years to each mm. Loop the thread around a toothpick wherever each event should lie. Paper labels identifying the "milestones" can be attached to the toothpicks. Students can hold the thread at their "event-station" until the model is complete, doubling back the thread as many times as is necessary to keep it within the available workspace. However, even the more generous scale allowed by the length of thread is not grand enogh to allow marking of any events since the last glacial retreat. So again, an expanded scale on a second spool is recommended. A scale of 1,000 or 2,000 years per meter is generous; 10,000 years per meter is adequate.

Extended Activities:

Have each student prepare a report on one of the events recorded on the Energy Calendar.

Discuss the relative importance of the events listed. Which was most important for mankind? for other living organisms? for the planet Earth? Make a list of the criteria suggested for selecting various priorities. Where does the class come nearest to consensus--on particular events (which may be chosen for different reasons) or on the criteria for selecting the most important ones (though the choices vary)?

Have the class (or selected representatives from it) show and explain its models to another class in your school.